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GEOLOGICAL SURVEY OF INDIA
Estd. 1851

GEOLOGICAL SURVEY OF INDIA

MISCELLANEOUS PUBLICATION No. 39

FIRST TWENTY-FIVE YEARS
OF THE
GEOLOGICAL SURVEY OF INDIA

BY

The Late Sir Lewis Leigh Fermor, F.R.S.

Formerly Director, Geological Survey of India

Published by order of the Government of India

1976

20 AUG 1977 MADRAS

FOREWORD

The volume deals with the formative years (1851-1876) of the Geological Survey of India under the stewardship of Dr. Thomas Oldham. A background panorama of the geological activities in India, prior to Dr. Oldham's arrival in 1851, is also included. Dr. Thomas Oldham, the founding father of this organisation, conferred upon it the influence of his well known name and the benefits of his experience acquired as the Professor of Geology, University of Dublin and the Director of the Irish Geological Survey. His enthusiasm, dedication and vision placed the organisation on a sound footing with a carefully built up strong infra-structure, the benefits of which were to be reaped in the years to come.

Sir L. L. Fermor, himself a stalwart in his own rights, has given a stimulating account of the geological activities of the first twenty five years, 'culling facts and figures from authentic documents. The narration runs in a chronological order, separated into the **Preliminary period** (1846-1851) and the **Continuous period** (1851-1876). The account displays the characteristic qualities of Fermor's patience, thoroughness and comprehensiveness.

The first twenty-five years is a remarkable period in the history of the Survey. The leadership of the Geological Survey of India over the entire period was vested in one person, who was both gifted and dedicated, namely Dr. Oldham. It was marked by constant endeavours on the part of the pioneer workers to look for fresh data and new interpretations to unravel the natural treasures concealed by the Mother Earth. The period also witnessed some of the most brilliant pioneering contributions of the Geological Survey of India to the earth sciences—isostasy, seismology and the conception of the super continent of Gondwanaland. It was during this period that the departmental publications such as Records, Memoirs and Palaeontologia Indica were systematised in uniform series. A scheme to train Indians in geological work was initiated during this period.

I am sure that this volume, being brought out on the occasion of 125th Anniversary of the Geological Survey of India, with the enthusiastic co-operation of Dr. W. D. West, will not only be of immense interest but will also take the readers back along the pages of history to marvel the noble qualities, missionary zeal and devotion to science of Dr. Oldham and his associates.

V. K. S. VARADAN
Director General
Geological Survey of India

Dated, 28th Nov., 1976
Calcutta-700013

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Sir Lewis Leigh Fermor
[1880-1954]

Born on September, 18, 1880 at Peckham London, Lewis Leigh Fermor obtained "First Class Associateship in Metallurgy with proficiency in Geology" from the Royal School of Mines, London in 1901. He was appointed as Assistant Superintendent in the Geological Survey of India in 1902 and, within a short period of two years, he rose to the rank of Deputy Superintendent. He became the head of the organisation, as Director, in 1932. He retired from service in the year 1935 and returned to England; the same year he was knighted.

During the tenure of 33 years of service in the Survey, Sir L. L. Fermor established his rightful place in the scientific world by many significant contributions in the field of geo-sciences. His monumental work on the "Manganese Deposits of India" brought him international fame; he also got a D.Sc. degree from London University on this work. He published about 150 scientific articles apart from two Memoirs and his regular contributions to the departmental Records. The present publication, being brought out posthumously, speaks amply of his scientific flair and facile pen.

Even after his retirement from service, Sir Fermor kept himself actively engaged with the pursuit of science. He passed away on 20th May, 1954 at Woking, Surrey, England.

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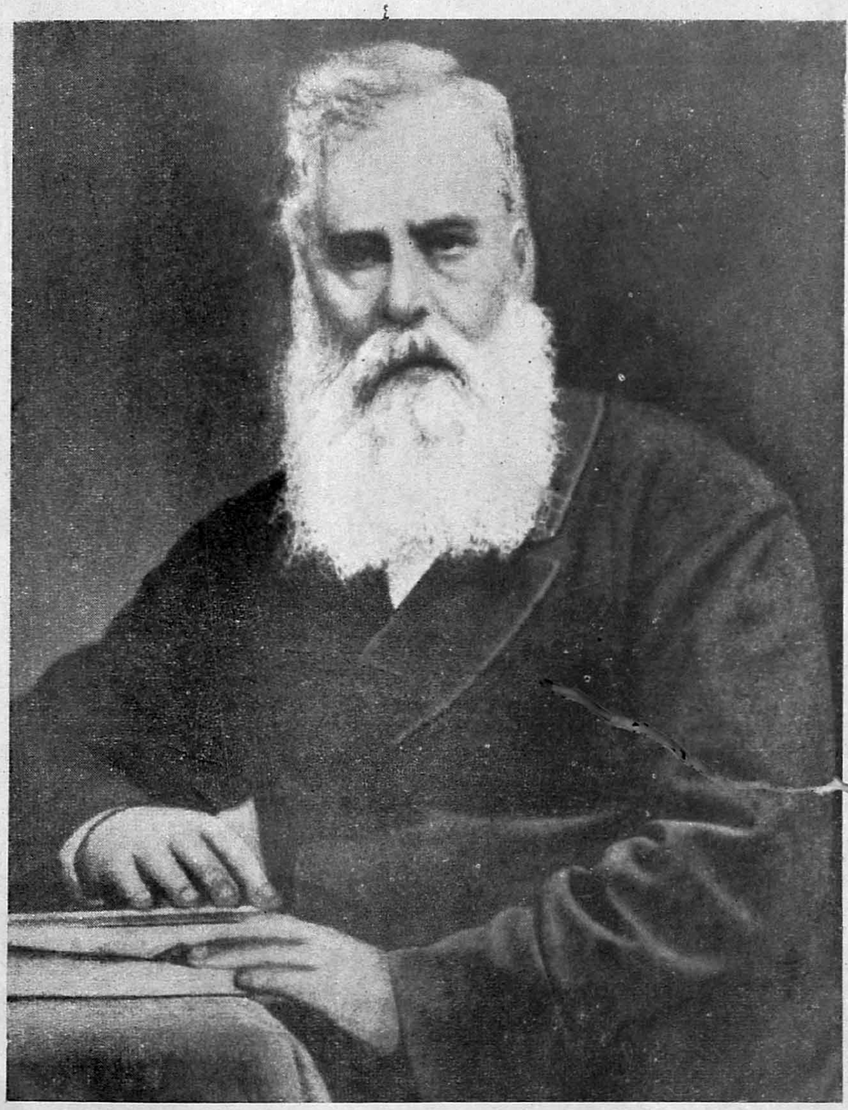

Sir Thomas Oldham
[1816-1878]

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PART I—PRELIMINARY PERIOD

CHAPTER I

INTRODUCTION

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In order to be able to write a short history of the Geological Survey of India we must attempt to decide when it began, and then be able to decide in what year the first century of its existence may be regarded as completed.

Date of commencement

Until recently it has been customary to regard the Department as having commenced in 1851, the year in which Thomas Oldham, the first Superintendent, arrived in India, although he was not at first called by this name but instead, Geological Surveyor to the East India Company. Oldham himself, however, seems to have dated the Department from 1856, judging from the titles of his Annual Reports of the Geological Survey. No copies of the first two reports appear now to exist, but the third report is entitled 'Annual Report of the Geological Survey of India, and of the Museum of Geology—Third year, 1858-59'. And similar reports with numbering consecutive with the third report exist up to that for the 'Tenth Year 1865-66'. The report for 1866-67 is unnumbered, but the next, which is incorporated in the first volume of the *Records of the Geological Survey of India* (June 1868) is entitled 'Twelfth Year 1867', the period of report having been changed to the calendar year. From these dates it is evident that to Thomas Oldham the first year of the Department is 1856[1]. The reason for this choice appears in the 'Preface' to the first volume of the *Memoirs of the Geological Survey of India* (p. v, 1859), which opens with the words 'When the Staff of the Geological Survey of India was increased in 1856, and its labours systematized, and extended to the Presidency of Madras....' But although Oldham regarded 1856 as the initial year of an **organised** Department, it is evident from the foregoing words that he regarded it as in existence prior to this year. This is not surprising in view of the fact that Oldham had arrived in India in 1851, and that prior to 1856 he had recruited to his staff the two Medlicott brothers (J. G. in 1851 and H.B. in 1854) and the two Blanford brothers (W. T. and H. F. both in 1855), and others, as well as William Theobald (1853),

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[1] Unless he meant the numbers, such as 'Third Year' to refer to the years for which reports had been prepared. See infra page.

who had done geological work in India prior to his arrival; and also in view of the fact that he had come out to replace D. H. Williams, the first man with the title of 'Geological Surveyor in the Service of the East India Company'. But we do not know whether Oldham regarded the unorganised period of the Department as dating from his arrival in India, or from that of Williams, especially as there was a hiatus between the death of Williams and the arrival of Oldham, a hiatus that was only partly filled by the officiating appointment of Dr. McClelland as Geological Surveyor.

Sir Thomas Holland, with evident knowledge of geological work in India prior to Oldham's arrival, in the Introduction to 'Indian Geological Terminology'[1] adopts 1856 as the date of 'formation of an official Geological Survey Department'. The present writer in an editorial on 'The Value of State Geological Surveys'[2] speaks of the Geological Survey of India having been founded in 1851, the year of Oldham's arrival in India, instead of 1856. This was doubtless written under the influence of the series of photographs of successive Superintendents and (later) Directors of the Geological Survey of India hanging in the Director's room in Calcutta, and the natural assumption that the Department dated from the arrival of its first Superintendent. H. B. Medlicott and W. T. Blanford, in their 'Manual of the Geology of India' (1879), write (p. lxxv) :

> 'Surveys of isolated tracts had previously been made by Captain Herbert, Mr. Williams, Dr. McClelland, Dr. Fleming and others for Government : but the regular examination of the country can scarcely be said to have commenced before 1851, if indeed its origin should not be placed somewhat later.'

Also, these authors write on the first page of the 'Preface' of the same work:

> 'The regular Geological Survey of India may be considered to have commenced in 1851'.

As these authors arrived in India in 1854 and 1855 respectively, they were in a position to know the facts, and evidently favoured 1851 as the initial year. Writing nearly a century after their arrival in India, we are not entitled to assume that we know more than they did concerning the commencement of the Geological Survey of India as a department.

However, of the two dates 1851 and 1856, Sir Cyril Fox (then Dr. Fox) in his work 'The Lower Gondwana Coalfields of India'[3] favoured the later date:

> 'And with the coming of Lord Canning (1856) a new era opened for

[1] Holland & Tipper, *Mem. Geol. Surv. Ind.*, XLIII, p.i. (1916) : Holland, *Ibid.*, Second Edition, LI, p.i. (1926) :

[2] Economic Geology, XXI, p. 181, (1926). See also Year Book, Asiatic Society of Bengal for 1934, p. 19.

[3] *Mem. Geol. Surv. Ind.*, LIX, p.3 (1934).

geological research in India. The Geological Survey was established as a proper Government Department and with it the new Museum of Geology was opened at 1, Hastings Street, Calcutta, on the 1st January, 1857'.

It will thus be seen that we shall be on firm ground if we regard the Geological Survey of India as having been definitely established as an organised Department in 1856. Such a decision agrees with the dating and numbering of Oldham's Annual Reports, and the year for celebrating the Centenary of the foundation of an organised survey would then be 1956, either the anniversary of the date of the renewal of Thomas Oldham's contract of service for a second period of 5 years (5.3.1856) or the 1st. April, 1856, the date of commencement of the first official year for which official reports were rendered to Government by Oldham.

Or, instead, it might be thought that the first five years of Thomas Oldham's service, during which he was organising the geological survey of India, could logically be included in the life of the geological survey of India even though the Department had not then been officially so named, although this name appears to have been used unofficially prior to 1856, and even prior to 1851. As the date of the commencement of Dr. Thomas Oldham's service is 5.3.1851, this could be taken as the birthday of the Department. In favour of the inclusion of this preparatory period of 5 years in the life of the Geological Survey of India is the fact that by 1851 much field work, the results of which are incorporated in the first two volumes of the *Memoirs of the Geological Survey of India,* had already been done by Oldham, the Medlicotts, the Blanfords and Theobald, whilst the foundations had been laid of the classification and the nomenclature of the Vindhyan and Gondwana formations, the names Vindhyan, Damuda, and Mahadeva being proposed by Oldham in 1856 (*J. A. S. B.*, XXV, p. 253, 1856).

Later, Sir Cyril Fox, whilst Director of the Department and after indulging in a search and examination of documents in the Geological Survey of India office and in the Bengal Government Archives in Calcutta, came to the conclusion that the commencement of the Department should be dated not from the arrival in India of Oldham, but from that of his predecessor, D. H. Williams. For, though there was a break between Williams's death and Oldham's arrival, nevertheless it is clear from the documents of the period that Oldham was recruited to replace Williams. Both were appointed with the title of Geological Surveyor, Williams being described as Geological Surveyor in the Service of the East India Company.[1]

The only difficulties in accepting this earlier dating for the Geological Survey of India are firstly that the Department had not been given that name officially, although the term was used in the title of the report written by Dr.

[1] Title of D.H. Williams as author of the two reports noticed in a later section.

McClelland,[1] who was Officiating Geological Surveyor for a portion of the time between Williams's death and Oldham's arrival; and secondly that Williams was not a Department, but a lone geologist working with a couple of nongeological assistant surveyors recruited in India before provision had been made for instruction in geology.

Sir Cyril Fox has, however, given his reasons for suggesting that the department should be dated from 1846[2]; and he suggested that I should also consult the original references in the India Office Library in order to assure myself that his suggestion was sound. Accordingly I have examined in the Library of the former India Office, now the Commonwealth Relations Office, all the documents mentioned.[3]

This led me to the discovery of other documents relating to geologists once in official employ in India prior to Williams; it will be useful to summarise the results of these further researches.

Holland and Tipper in the work already cited (*loc. cit*, p. 1) give a long list of geologists, many of them enthusiastic workers, who devoted their leisure time to research in the geological field in India.[4]

It is only those who were officially employed on geological work who can be considered here, namely, Laidlaw, Dr. H. W. Voysey, Capt. F. Dangerfield, and Capt. J. D. Herbert, all prior to Williams; whilst those employed after Williams's death and prior to the arrival of Thomas Oldham, comprise J. McClelland, W. Theobald, Dr. A. Fleming and William Purdon.

Of those geologists employed prior to Williams, none was brought out from Europe specially for geological work.

It seemed at first that Laidlaw was an exception to this statement, but an examination of the papers shows that although he came to India known to be possessed of mineralogical attainments, yet he came at his own volition,

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[1] 'Report of the Geological Survey of India, for the Season of 1848-49', Calcutta, 1850.

[2] Presidential Address to the Mining & Geological Institute of India. *Trans.*, XXXI, p. 19, (1936). And *Nature*, Vol. 160, p.889, (1947).

[3] The various references in Chapters I to IV to 'Board's Collections', 'Bengal Dispatches, 'India & Bengal Dispatches' and 'Home series Miscellaneous', are the volumes of documents preserved in this Library.

[4] A complete history of geological research in India would, of course, necessitate notice of the work of all these other numerous pre-Oldham geologists. Such an account would swell this history unduly and is not really appropriate. Nevertheless, it is pleasant to be able to invite attention here to Sir Clements R. Markham's 'A Memoir on the Indian Surveys', 1871, which contains a section on the Geological Survey of India (pp. 145-169) in which the labours of these early investigators are ably summarised (pp. 145-154). This work also contains, on pages 302,303 a tabular statement of the staff of the department up till 1871, this statement being replete with useful facts.

and was engaged for mineral survey work only after his arrival. The remaining three were already in employ in India in other capacities before they were enabled to turn to geological work. Thus, Voysey was a surgeon in the employ of the East India Company, whilst Dangerfield and Herbert were officers respectively of the Bombay Native Infantry and the Surveyor-General's staff. The official titles of these four whilst on geological or mineralogical work were 'Mineralogist to the Survey of Kemaon' (Laidlaw): Surgeon and Mineralogist (or Geologist) to the Superintendent, Great Trigonometrical Survey (Voysey); 'Geological Surveyor to the Himalaya Mountains' (Dangerfield); and 'Geological Surveyor to the Himalaya Mountains' (Herbert). Herbert, in the posthumous report on his work on Kumaon and Garhwal, is described as 'Superintendent of the Mineralogical Survey of the Himalaya Mountains'.

Of these officers, Laidlaw was attached to the Surveyor General's Department, and Voysey to the Great Trigonometrical Survey; whilst Dangerfield and Herbert reported direct to the Government of India. We must also mention here Dr. A. Fleming, another surgeon, who was 'In charge of the Geological Survey of the Salt Range in the Punjab' from 1850-1852 (after a report made in 1848). Fleming's period of work overlapped the arrival of Oldham; his reports were submitted to the Secretary to the Board of Administration for the affairs of the Punjab.

From the above data it will be realised that although there was a considerable amount of geological survey work in India prior to the arrival of Williams, yet Williams was the first geologist to be recruited abroad specially for geological work in India; moreover, he was recruited to a post, namely Geological Surveyor to the East India Company, that through his successor, Thomas Oldham, became that of Superintendent of the Geological Survey of India. But the term Geological Survey of India was not used in Williams's time, and also he was a lone geologist (his two assistants being topographical surveyors): further, there was a hiatus in geological work between his death in 1848 (only partly filled by McClelland as Officiating Geological Surveyor) and the arrival of Oldham. Consequently, it seems that the best solution of the difficulty in choosing between 1846 and 1851 as the date of commencement of the Geological Survey of India is to regard 1846 to 1851 as a *Preliminary Period*, and from 1851 onwards as a *Continuous Period*, and this history has been laid out on this basis.

In the following sections we propose to discuss first the early official geologists, (Laidlaw, Voysey, Dangerfield and Herbert), and then in a separate section on the Preliminary Period, the work of Williams and McClelland, also including here for chronological reasons the work of Fleming. The *Continuous Period* dating from Oldham's arrival in 1851 will be treated in sections according to successive Directors.

Changes in the territories of India

This seems to be a suitable point at which to emphasise that to write a history of the Geological Survey of India is not as simple a task as for the Geological Survey of Great Britain, as presented by Sir John Flett[1], for the very good reason that whereas in the case of Great Britain the area of the territory covered has remained constant, in the case of India it has varied due to the remorseless operation of historical causes, first expanding and later contracting. The phase of expansion can be realised by consulting an Atlas, such as the Atlas of the Imperial Gazetteer of India, 1931 edition, in which is given a series of maps illustrating India at successive dates (1765, 1805, 1837, 1857 and 1931) showing the variation in the distribution of territory, British and non-British (Hindu and Moslem), and also the extent to which the total area comprised under the term 'India' has varied. Thus, in the north-west the Indian frontier was on the Indus river as late as 1805, Peshawar and much of the tribal territory then being extra-Indian. Even in 1857, Baluchistan was not part of India.

At this date, the portion of India known as British India had long been under the rule of the Honourable East India Company at India House in London, represented in India by the Governor General in Council. But on the 1st November, 1858, the Government of India was transferred to the Crown by royal proclamation drafted in accordance with Queen Victoria's expressed wishes, and Lord Canning was appointed as the first Viceroy and Governor-General. On the 1st July, 1877, Queen Victoria was declared *Kaisar-i-Hind*, or Empress of India, and India became the Empire of India.

Burma and parts of Assam did not come into the Indian sphere until the three successive Burmese wars, bringing additions of Burmese territory in 1826, 1852 and 1886 respectively, Burma being finally annexed to India in 1886. Upper and Lower Burma were united into a single province under the Government of India in 1897.

Baluchistan, including Kalat and Quetta, had entered the Indian orbit by treaty in 1876; but the position of the frontier between India and Afghanistan as represented by spheres of influence was not settled until 1893, and the demarcation of the 'Durand Line' from Chural in the north to the Zhob Valley in Baluchistan was undertaken by a boundary commission during the next few years.

Lord Curzon, who became Viceroy of India on the 3rd January, 1899, thus came to India at its time of maximum extension, an extension that continued until 1st April, 1937. At this time of maximum extension of the Indian Empire, as it was then called, the sphere of the operations of the Geological Survey of India reached from the Persian-Baluch frontier on the west to the Burma-China frontier on the east, and from the farthermost parts of Chitral and Kashmir in the north to Cape Comorin in the south; truly a magnificent terrain, including in its range, parts of the highest mountain chain on earth,

[1] "The First Hundred Years of the Geological Survey of Great Britain", (1937).

contrasted with the fertile alluvial plains, in part densely populated, of the Indus, the Ganges, the Brahmaputra, and the Irrawaddy river, the deserts of Baluchistan and Rajputana, the hilly jungles of the Peninsula, and the pellucid seas of the Nicobar & Andaman Islands; with climates varying from the delightful alpine climates of Kashmir, Simla and Darjeeling, with their majestic vistas of the snowy ranges of the Himalaya, to the hot dry climate of Upper India and the humid deltaic climate of Bengal and Calcutta.

Towards the end of this period of maximum extension of India there began a tendency to retraction, and with the political changes introduced on the 1st April, 1937, Burma was separated from India and ceased to be subject to the Government of India. The writ of the Geological Survey of India no longer ran in Burma, and a new Department called the Burma Geological Department was formed, officered at the beginning by officers lent from the Geological Survey of India. This was not the only retraction, for it is recent history that in 1947, on the 15th August, the Indian Empire came to an end and was divided into two dominions, India and Pakistan. A new Geological Survey, that of Pakistan, was formed, and the scope of the Geological Survey of India was retracted to that of the Dominion of India, which became a Republic on the 26th January, 1950.

Dating from Williams's arrival the Geological Survey of India had endured 101 years by the time of the partition into the two dominions, whilst the Continuous Period of the Department will have lasted 100 years by 1951.

Territorial scope of the Geological Survey of India

The immense terrain comprised by the term India prior to 1937 was not politically uniform, for it comprised two major elements. The first, known as British India, was divided into provinces and was under the control of the Government of India (and ultimately of the Secretary of State for India in London): the second element comprised the Indian States, each State under its own ruler and each possessing its own system of government, but in liaison with the Viceroy on behalf of the Crown, a liaison maintained by the Political Department of the Government of India.

The Geological Survey of India in its field work treated the whole of British India and Burma as within its normal sphere of operations. The Department also worked in the Indian States, but in such cases special arrangements were made with the States through the Political Department of the Government of India, and the cost was normally borne by the departmental budget unless the Department had been asked by the State to supply an officer for a particular investigation that required a departure from the normal sequence of the Department's scheme of systematic survey. Of more recent years some of the Indian States have established their own Geological Survey Departments; Mysore since 1.10.1894, Kashmir since 1917 and Hyderabad since 1931 being the most notable examples, the first two surveys being organised by officers retired from the Geological Survey of India namely, R. Bruce Foote, and C. S. Middlemiss respectively. Brief one-man surveys have been

made of some other States, e.g. Baroda (Foote: 1898), Mayurbhanj, (P. N. Bose: 1904), and Rewah (K. P. Sinor: 1923).[1]

Authorities under whom geological work in India was conducted It is of interest and importance to record here the various authorities under whose orders the Geological Survey of India has been carried on.

The important dates are as follows :-

1846 to 1851	The East India Company
1851 to 31.10.1858	-do-
1.11.1858 to 1.7.1877	The Crown (Queen Victoria)
1.7.1877 to 15.8.1947	The Crown : The Empire of India.
1.4.1937	Burma given Dominion Status.
15.8.1947	Indian Empire partitioned into two Dominions, India & Pakistan.
15.8.1947 to 26.1.1950	The Dominion of India
26.1.1950	India becomes a Republic.

1846-1858 British India ruled by the East India Company with a Court of Directors in London, represented by the Governor-General at Fort William in Bengal.

1858-1947 India ruled by the Crown acting through the Secretary of State for India at India House in London, represented in India by the Viceroy and Governor-General.

1947-1950 India independent with Dominion Status, with a Governor-General representing the Crown, but appointed on the recommendation of the Indian Parliament.

1950 India assumes Republican Status within the Commonwealth, with a President instead of a Governor-General.

From the above it will be seen that the gazetted officers of the Geological Survey of India have been appointed by various authorities as follows:-

1. By the Court of Directors of the East India Company, 1846 to 1858. All officers from Williams to Bruce Foote.

2. By the Secretary of State for India from 1858 to 1926. All officers from F.R. Mallet to M.S. Krishnan, P. Leicester, and S.K. Chatterjee.

3. From 1926, the Government of India made their own appointments, and in cases where officers were apparently appointed in London by the Secre-

[1] In addition, we may note the appointment in 1862 of Frederick Drew as geologist to the Maharaja of Kashmir, during which service he became Governor of Jammu and later of Ladak. He returned to England in 1872. Prior to going to Kashmir he was in the Geological Survey of Great Britain (1855-1862) as Assistant Geologist.

tary of State for India, the latter was acting as the Agent of the Government of India. J.B. Auden was the first officer to be appointed in this way.

4. Appointments are now made mainly in India; where made in London they are made by the High Commissioner for India acting on behalf of the Government of India.

Conditions of Geological field work

The long period from the days of Williams and Oldham to the present day has of course been characterised by great changes in the conditions of geological field work. This change has been due in the main to two causes; one, the progressive opening up of the country with the extension and improvement of roads and the introduction of railways and telegraphs: the other, the vast strides made in the knowledge of tropical diseases, particularly of the cause and treatment of malarial fever.

Thus, although surveys for the construction of railways began on both sides of India in 1845, the first line was not opened until the 16th April,.1853, this being a section of the Great Indian Peninsular Railway from Bombay. The first telegram from Agra to the Governor-General in Calcutta was sent on the 24th March, 1854. The first adhesive postage stamp was the famous Scinde District Dawk Stamp of the 1st July 1852, followed by the general issues of the Honourable East India Company from April 1854, lithographed in the Surveyor General's office in Calcutta.

Williams, it will be seen, arrived before any of these aids to improved communications were introduced; they all appeared during Oldham's first five-year period of service.

In practice, in the days of Williams and for some decades afterwards, the most important aids to transport in the Peninsula of India were those that had prevailed in India for centuries, namely the elephant, the bullock cart, the camel, the horse and the coolie. Williams obtained the means of transport from the Commissariat Department, but later the Geological Survey built up its own herd of elephants, and officers set out for camp from Calcutta by road with their baggage on elephants, and themselves mounted either on elephant or horse,[1] which they also used locally at the field of survey. Tradition[2] has it that some of these elephants were trained to pick

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1 Or sometimes carried by *Palki* or Palanquin

2 Tradition must not be disdained in these matters, for personal servants must have been handed on from one geologist to another. Moreover a century is not a long time from some points of view. I myself was interviewed for appointment to the Geological Survey of India in 1902 by Dr. W.T. Blanford who himself had arrived in India in 1855. So that in five years from now he and I together will have spanned a century.

Since writing the foregoing part of this footnote I have discovered a passage in Hooker's 'Himalayan Journals', Vol. I, p.10, (1854), that confirms tradition. Recording a journey in 1848 in company with Williams on an elephant provided by Williams, the author writes:—

'Our elephant was an excellent one, when he did not take obstinate fits, and so docile as to pick up pieces of stone when desired, and with a jerk of the trunk throw them over his head for the rider to catch, thus saving the trouble of dismounting to geologist.'

up pieces of rock and hand them up to master for his inspection and decision whether it was necessary to dismount and make a closer examination.[1]

The Department has long ceased to own its own elephants, but this means of transport is still sometimes used in the wilder parts of the Peninsula and Assam.

In the drier and desert parts of Rajputana and North-West India the camel has been the age-long means of transport, and until recently officers working in the Central Provinces arranged for strings of camels to be sent down from Rajputana or the Punjab for the season's work.

But in the less-wild parts of the Peninsula the standard means of carriage of camp equipment is still the bullock cart.

In many parts, however, neither elephant, camel nor bullock cart is, for one reason or another, either suitable or available. In the Himalaya and parts of Upper Burma mules, where there are suitable tracks, and coolies, where there are not, have long been the standard means of transport. In the peninsula also, in some of the backward tracts, such as the former Chhatisgarh Feudatory States, coolies are *de rigueur*, except when pack bufalloes can be obtained. Coolies can be surprisingly satisfactory and efficient if their employer is tactful and sympathetic.[2]

There is one other mode of transport necessary in some parts of India and Burma, namely water transport. In Tenaserrim in Burma, and on the west coast of India, and in the riverain tracts of Bengal and Assam, water transport is necessary, and for this purpose a variety of country boats exist.

It is an axiom, however, that 'geology is done by walking.' The geologist can use an elephant, camel, horse or bicycle, and sometimes nowadays motor transport, to reach the scene of work; and such adjuncts may be very useful at the end of the day, especially if it is not convenient to camp close to the work. For this reason, until recently, ability to ride has been necessary, and formerly, at the time of appointment, those who could not already ride were expected to take lessons in horsemanship before proceeding to India.

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[1] That geology in India was sometimes done from a distance was humourously suggested one day by Mr. Walcott Gibson when Pilgrim and I were training under him in Derbyshire after our appointment to the Geological Survey in India in 1902. Whilst crawling along a ditch looking for exposures under bushes Gibson said that, of course, this training would be of no value to us, as once we were in India we should ride on horses and survey through a telescope. In practice, Pilgrim was sent to the Persian Gulf, where he did at times work in the manner suggested, but I myself was often involved in more detailed work where Gibson's training was of value.

[2] As an illustration of this I may mention my own record march with coolies made in 1912, namely on my return accompanied by Bankim Bihari Gupta, from Korea State to Pendra Road Railway Station, where the coolies were to be released for return to their homes. The number of coolies was about 100, and they did a 28-mile march in 7 hours carrying very considerable quantities of camp equipment. Bankim and I travelled by elephant and found the whole 100 waiting for us on our arrival'.

Language requirements

Officers were also encouraged to take lessons in Hindustani or Urdu as early as possible, and an incentive to this was provided by the date of the first increment of pay being the date of passing the test in Lower Standard Hindustani or Urdu; so that several officers obtained this increment well before the year was out. Hindustani is the *lingua franca* of much of India; but in Southern India, and in the country of the aboriginal tribes of Chota Nagpore, Hindustani is not understood off the beaten track, and it is necessary to have an interpreter attached to one's camp. This was still more necessary in Burma, where official provision was made for the pay of an interpreter to accompany each officer. In all these cases the knowledge of a few words of the local language by the geologist sometimes produces so magical an effect as to justify the study of the local language apart from the interest thereof[1].

Officers working in the Peninsula of India in tracts where ample transport was obtainable—elephants, camels, carts or coolies—used to camp with a large amount of equipment with stores and servants for six months at a time away from headquarters. Large tents were used (but less large than those favoured by district officers), and a normal amount of transport was some 5 or 6 bullock carts or a string of 10 camels. In the very earliest days the camps must have been much larger. Thus it is recorded[2] in a letter dated 25.11.1848 from Kallynauth Mozoomdar, sub-Assistant Surveyor to Haddon after the death of Williams, and after the camp had been brought back to Hazaribagh on account of fever, that the number sent to hospital comprised 5 bullock drivers, 5 *khalasis*, 2 *mahouts*, 12 private servants, including women, 8 children, and one *burkundaz*: in addition, there was a considerable number of people in camp who had but recently recovered from fever.

Tropical diseases

In the early years of the Geological Survey of India, before the cause and treatment of tropical diseases was known, the mortality of those who went into the jungle was very high. Officers went too early into camp after the rains, whilst mosquitos were still virulent, and when it was not known how necessary it was to take every possible measure to avoid the bite of the mosquito, and what was the proper treatment should fever appear. Williams's death, that of his assistant Brady Jones, and the high incidence of fever amongst his servants recorded above, were due no doubt to such causes. But for many years geologists continued to die prematurely, malaria and its complications, liver, sunstroke and cholera, all taking their toll. And in one Annual Report[3] Oldham records that up to date the average duration of life in the Geological Survey was only a fraction more than nine years. In fact, the losses of the Geological Staff in its early years were so serious that

1 Thus two words of Ho—*simko ra*, meaning 'at cock crow' — caused a Ho coolie's face to become illuminated, and him to arrive at my camp before dawn the following morning in time for the day's work in the jungle, when previously he had been very tardy.

2 Board's Collections, Vol. 2325, Coll. 121006, 1848-49.

3 Eighth Year. 1863-64 p. 15. He relates the experience of 17 years, i.e., from Williams's arrival.

Oldham records in the Annual Report for 1870[1] that Assurance Offices declined to accept insurances on the lives of officers of the Survey stating that 'no premium whatever could cover the risk'.

With the passage of years the mortality among geologists has decreased, but it was Ronald Ross's discovery of the cause of malaria—the mosquito bite—in 1898, that at one stroke, a stroke producing knowledge, made the jungle more healthy for geologists[2]. Nevertheless, the geologist is still subject to greater risks from exposure, illness and accident than the town dweller, and for this reason officers of the Geological Survey of India long had the right to take a minimum pension after 20 years' service.

Wild animals and *Shikar*

It is often thought that snakes, tigers and other wild animals must prove a menace to those whose work lies in the jungles of India. Snakes, however, are not much of a danger to the geologist, as he usually goes heavily shod with his legs encased in *putties* or gaiters; moreover, during the Indian winter and early hot weather, which is the usual field season of the geologist, most of the snakes are dormant, and at the time when they abound, which is principally the monsoon or rainy season and the later hot weather, the geologist is usually at headquarters at work upon his maps and reports. Only one fatality amongst geologists due to snakes is known to the present writer, namely the death of Mr. Kelsall Slater of the Mysore Geological Department; but he brought his accident upon himself by deliberately jumping upon a cobra.

On the whole, in the jungle, the animals hear the geologist coming and avoid him; and accidents only occur if an animal is cornered or surprised and cannot easily escape. It was thus that Mr. Francis Walker was fatally gored by a saing (*Bos sondiacus*) in Burma in 1925[3] whilst Dr. E. H. Roberton, formerly of the Sibpur Engineering College, was attacked and mauled by a bear with two cubs which he accidentally encountered in a river bed whilst prospecting in the Bokaro coalfield. A similar accident nearly befell the present writer, also in the Bokaro coalfield, but fortunately there was a way of escape for mother bear and her cubs. A different type of accident occurred to Mr. D. S. Bhattacharjee when he fell down a covered pit made as a tiger trap; it was some months before he had fully recovered from his fall.

To some geologists, service in India has provided unrivalled opportunities for big-game hunting. Theodore W. H. Hughes proved to be our Champion

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[1] *Rec. Geol. Surv. Ind.*, IV, p.2

[2] The writer of this passage was lucky in that he did not arrive in India until 1902, by which time the full significance of Ross's discovery was known: by treating the mosquito as a deadly enemy it was not until he had been in India 24 years that he experienced his only attack of malaria. By this time also the necessity of boiling water and milk etc., as a preventive against water-borne diseases such as cholera, dysentry and typhoid, was fully appreciated.

[3] Rec. *Geol. Surv. Ind.*, LVIII, p. 81.

Shikari, and is reputed to have shot over 100 tigers and 500 bears during his service. He was mainly engaged on the survey of coalfields, where there is often running water and the caves beloved of both tiger andbear. Hughes is said to have secured his great bag of tigers by a system of rewards for information: one rupee for *khabar* (news) of a coal seam and two rupees for *khabar* of a tiger[1]. The abundance of tigers in some parts of India does not mean that they are often met accidentally. They have to be sought out. Valentine Ball tried for the whole of his service to shoot a tiger. He secured many bears, but the tiger eluded him until nearly the last chapter of his fascinating book 'Jungle Life in India; or the Journeys and Journals of an Indian Geologist[1]' which is and probably will always remain the classic work descriptive of the life of a geologist in India[2].

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[1] Aided, of course, by the services of a skilled *shikari*. After Hughes's premature retirement due to a shooting accident (he was blinded by bird shot from a colleague's gun) his *shikari* was employed by one of the officers of the Central Provinces establishment, who was also helped thus to secure a hundred tigers. From a conversation I had with Mr. Prideaux some years ago in Nagpur, I have no doubt that the bag ascribed to Hughes must be regarded as authentic.

[2] De La Rue & Co. Octavo, 1880.

CHAPTER II

EARLY OFFICIAL GEOLOGISTS

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Pioneers of Indian geology

In the 'Introduction' to his Indian Geological Terminology Sir Thomas Holland gives a list of the pioneers of Indian geology outside the ranks of the Geological Survey of India. Only four of these pioneers were officially employed for their mineralogical or geological knowledge, namely Laidlaw, Voysey, Dangerfield (overlooked by Holland) and Herbert, in the years prior to the arrival of Williams[1]. Their contribution to the progress of geological survey in India will be noticed in the present chapter. One other was officially employed as a geologist, namely Dr. A. Fleming (with William Purdon), but though he was not in any way connected with Williams and the Geological Survey of India, his work with that of Purdon will, for chronological reasons, best be noticed in the chapter discussing the Preliminary Period of the Geological Survey of India.

For accounts of the work of some of the other pioneers, namely those who were engaged in geological research as an adjunct to their normal official duties in some other capacity, the reader can with advantage consult Dr. H J. Carter's 'Geological Paper on Western India' (1857) in which 42 papers have been collected—reprinted—in full or in abstract, from a great variety of sources dated between 1815 and 1857. Otherwise the work of these early writers can be discovered by consulting, in La Touche's Bibliography of Indian Geology (1917), the names of the pioneers as enumerated by Holland[2].

One of these early non-official geologists must, however, be mentioned here as the most eminent geologist in India prior to Thomas Oldham, namely Capt. T. J. Newbold of the Madras Army, who was an Assistant Commissioner

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[1] In addition, Colonel R. H. Phillimore, who is engaged in editing and publishing the Historical Records of the Survey of India has drawn our attention to Adam Hotchkis an Assistant Surgeon on the Bengal Establishment, who was, in 1779, appointed Mineralogical Surveyor under the Government of Bengal. He was murdered at Curicholea in the beginning of 1782 in an insurrection. After this, the post which had been purely experimental, was abolished. The reference given by Col. Phillimore is to Volumes 356, p. 79, and 358, p. 51 of Home Miscellaneous Series.

[2] Also see Sir Clements R. Markham's 'A memoir on the Indian Survey', pp 145-154, 1870

in Kurnool, and later Assistant Resident at the Nizam's Court, Hyderabad. Newbold's work was on the geology of the Peninsula, for which he was elected F.R.S. in 1842. According to his gravestone in the churchyard at Mahabaleshwar he 'suddenly passed away in the midst of his studies at Mahabaleshwar on the 29th May, 1850 aged 40 years'.

It will be useful to note on each of the four early pioneer geologists named above in order of their appointment.

Laidlaw: Mineralogist to the Survey of Kumaon, 1817-1821

The first man officially employed in India for geological work was Mr. Laidlaw (initials not known), who was attached to 'the surveying establishment under Lieut. Webb, in the province of Kumaon, for the purpose of exploring the mineralogy and natural history of that country'[1]. Later[2], Laidlaw is referred to in Bengal Public Letter dated 15.2.1821 as having been 'appointed Mineralogist to the Survey of Kumaon in 1817'. As he had not furnished reports of his researches the services were terminated by the Government of Bengal by the suspension of his allowances; moreover, he was not allowed to remain longer in India, as the period for which he had the permission of the Court of Directors had already expired. The Court of Directors in commenting on this episode, disclaims responsibility for Laidlaw's appointment in the following words[3]:

> 'Upon reverting to the passage, para 18, in our letter in this Department, dated 11th Oct. 1916 you will find that we expressed nothing more than our permission that Mr. Laidlaw should proceed to India in prosecution of his researches in mineralogy and natural history, of his proficiency in which branches of useful knowledge we had received a favourable account'.

This means that Laidlaw's appointment as Mineralogist was made by the Governor of Bengal in India, so that Laidlaw cannot be claimed as a geologist appointed in England for service in India, and thus, a predecessor to D. H. Williams in this respect. Concerning this episode Sir Clements Markham remarks[4] that 'Laidlaw was a very able man, and is said to have been badly treated'.

Dr. H. W. Voysey: Geologist to the Great Trigonometrical Survey, 1818-1824

We now come to the man sometimes known as the Father of Indian Geology, namely Dr. Henry Westly Voysey. To fill a medical vacancy he was, in 1818, appointed surgeon to the Great Trigonometrical Survey, under the Superintendence of Lieut. Col. Lambton[5]. Voysey was selected for this appointment because of his geological knowledge. In the discussion on this

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1 Bengal Despatches, Vol. 89, 13.6.21 to 15.8.21, pp. 709-713. Extract from a letter dated 29th October, 1817 from Bengal to the Court of Directors in London.

2 Bengal Despatches, Vol. 94, 4.6.1823 to 26.11.1823, p. 861.

3 Bengal Despatches, Vol. 89, pp. 712, 713.

4 *Loc. cit*, p. 145.

5 Board's Collections, Vol. 70. 679, Collection No. 18861, pp.417-425.

proposal one of the Vice-Presidents to the Governor General's Council at Fort William in Bengal, made the following, amusing comment to us (*Ibid.*, p. 419):

> 'The scientific assistance which Mr. Voysey is to give the Survey is a distinct consideration, I understand that persons properly qualified by their knowledge in Geology have been attached to the great Survey carrying on in England. It is probably my want of knowledge of the subject that renders me desirous of being satisfied, whether these exquisite refinements of science are practicable in this Country'.

In 1819, Voysey,in a letter to Lambton (*Ibid.*,p. 425) states that so much of his time has been taken up in 'mixing up medicines and dressing that he has had very little time to attend to his Geological pursuits', and mentions the great convenience that would accrue from his having a Dresser attached to him. As a result a Dresser was sanctioned.

In a later letter[1] Lambton suggested to Government that Voysey 'the Surveyor (or Surgeon, writing not clear) and Mineralogist to the Survey, should proceed separately to Agra and return by the tract of country through which Lambton proposed to carry the Great Triangle and report to Lambton on the practicability of the work'. Voysey's geological work was now taking precedence over his medical duties, and Lambton recommended that Voysey should be made one of his assistants. This was refused because when Voysey was at a distance from Lambton's Headquarters he was relieved of his duties as Surgeon, and, when reunited with the Survey Government, doubted the expediency of combining in one individual the functions of Surgeon, Geologist, and Assistant. Instead, Voysey was authorised to draw an extra Rs. 200 per mensem.

Later, in an answer to Public Letter dated 1.10.1823 occurs the sentence 'Mr. Voysey has been attached as a Geologist to the establishment of the Superintendent of the Great Trigonometrical Survey of India'.[2] This letter also advised the despatch of a report and of specimens of minerals collected by Voysey to the Court of Directors.

Voysey died of fever on the 19th April, 1824 whilst on his way from Nagpur to Calcutta, and arrived at Howrah dead in his Palki.

During this short period of 5 years Voysey made the first contributions to an understanding of the geology of India, contributions that justify the title of Father of Indian Geology. La Touche in his Bibliography attributes seven papers to Voysey, including extracts from his Journals. They all appeared in *Asiatick Researches* and the successor thereto, the *Journal of the Asiatick Society of Bengal,* between the years 1824 and 1844 (his Journals), and thus all appear to be posthumous. But he had during his lifetime submitted a geological

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1 Board's Collections, Vol. 750, 1823-34 & 1824-25. Bengal Military Deptt. Coll. No.1 of 20515, p. 135. Public letter dated 1.10.1822.

2 Bengal Despatches, Vol. 94, p. 172.

report dated Secunderabad, 28th June 1820, signed by him as 'Surveyor and Naturalist attached to the Grand Trigonometrical Survey'. This report was accompanied by a geological map, drawings and a box of specimens of rocks and fossils, all of which were forwarded to the Court of Directors in London[1]. This report consists of 60 pages of foolscap manuscript (*Ibid.*, pt. 90, 96-156) and is followed by a list of plants and animals examined by Voysey that was intended to form the commencement of a fauna *Hyderabadiana.* A letter from Voysey to Lambton dated Hyderabad 8.6.21 refers to further work and contains two important passages. The first (*Ibid.*, p. 90) has a very modern sound:

> 'In addition to the great advantage to Science and to the Arts from a knowledge of the Geological structure of this Country obtained from Section Maps and collections of Specimens, I conceive that a very important object of a Geological enquiry lies in determining the cause of these anomalies which sometimes occur in Trigonometrical operations and which can only be explained by supposing them to arise from concealing disturbing forces owing to difference in the specific gravity of the upper, lower or contiguous strata.
>
> 'The error in Latitude at Arbary Hill in the Trigonometrical Survey of England, supposed first of all to have arisen from the imperfection of observations or of instruments has since been attributed with great probability to the above-mentioned cause'.

And the second (*Ibid.*, pp. 92) contains a broad statement that illustrates the width of country over which Voysey's travels had extended. He had arrived at:

> 'The conclusion that the basis of the peninsula of India from Cape Comorin to the parrllel of Nagpur is of Granite, the constituent parts of which are nearly similar, and that the Superincumbent rock where any exists rarely exceeds 1,000 or 1,500 feet in height'.

Captain F. Dangerfield: Malwa, and Geological Survey of the Himalaya Mountains, 1820-1822

The third geologist to be noticed is Capt. F. Dangerfield of the Bombay Native Infantry, who served under Sir John Malcolm in Central India as scientific officer during the years 1820 and 1821, making meteorological, geographical, astronomical and geological observations[2]. Dangerfield's 'Report on the Geology & C., of Central India' constitutes Appendix II of this Memoir (Vol. 2, pp, 313-349, 2nd. Ed.), the frontispiece of the second volume being 'A Geological Sketch of Malwa and part of the Adjoining Provinces'. This is a hand-coloured map on the scale of roughly 25 miles to an inch, extending from Baroda and the Narbada river in the south to Udaipur Nimach and Bhanpura in the north. The geological formations represented are named on a lithological basis, ranging from granite and gneiss through slates, porphyries, limestones and sandstones to the overlying trap and allu-

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1 Board's Collections. Vol. 782, Collection 18864, pp. 87-156.

2 Major-General Sir John Malcolm, 'A Memoir of Central India including Malwa and adjoining Provinces'. In two volumes, London, 1823. Second Edition, 1824. Vol.1. page 7 (2nd Ed.)

vium[1] and include Aravallis, Delhis, Vindhyans, and Deccan Trap of our modern nomenclature. The boundaries are, of course, exceedingly rough and often very different from those now recognised, formations of quite different ages being sometimes hopelessly confused one with another. Nevertheless, the map does bear a crude resemblance to the modern map of this part of India, and it must be regarded as the first published geological map of a part of India, though the map of a part of Hyderabad and adjoining country that Voysey submitted to the Court of Directors in 1820 (already mentioned, supra page), probably takes precedence by about one year in date of construction.

Dangerfield's geological work for Malcolm was apparently finished in 1820, and his meteorological work by the end of January 1821[2]. Immediately after (10.2.21), Malcolm wrote to the Survèyor General of India concerning the further employment of Dangerfield[3].

Malcolm's original idea had been that Dangerfield should be employed making geological and other enquiries in the Central and Western Ranges of hills of the Peninsula; but later, both he and Dangerfield desired that the the latter's operations should be in the Northern Mountains and the Himalaya Range instead (*Ibid.*, p. 418). Eventually, Dangerfield was informed, whilst he was on a Mission to Siam and Cochin China, that on his return it was the intention of the Governor General in Council to employ him in conducting mineralogical and geological investigations in the 'Northern Mountains and in the Himalaya Range'. The tract to be examined was that 'Comprehended between the Sutledge on the West, and the Kali which bounds Kemaoon on the East'. Dangerfield was given a free hand as to how he did his work, in the following terms:

> 'The tract of Country designated at the commencement of this letter has been chosen as the scene of your employment both on account of the intrinsic value and importance of its Geology and Mineralogy and of the degree of interest with which the investigation of them is understood to be expected by the scientific world in Europe. It is believed that an Accurate knowledge and lucid description of the formation and productions of the region in question are peculiarly calculated to confirm or correct existing Theories and Systems, and to enlarge the boundaries of Geological Science and eventually to contribute to the improvement of the resources and wealth of the Country. With these views but on a more limited scale a skilled Mineralogist was attached to Capt. Webb's Survey of Kemaoon'.

The last sentence refers to Laidlaw's employment, and the Governor General in Council now hoped for a better result, especially as Dangerfield's attainments appear to have been regarded highly. Dangerfield's employment was to be directly under the Governor General in Council, and not under the Surveyor-General (*Ibid.*, p. 436).

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[1] See *Mem. Geol. Surv. Ind.* II, p. 101, for J.G. Medlicott's tribute to the quality of Dangerfield's work.

[2] *Ibid.*, Vol. 2, Appendix III, p. 353.

[3] Board's Collections, Vol. 682, 1823-24, Collection 18864, pp. 407-452. See page 407.

Dangerfield eventually joined his new appointment, but quite soon resigned from *ill health*; and, according to a letter dated 1st Jan., 1823, Captain Herbert was appointed 'Geological Surveyor of the Himalya Mountain' in his place[1]. Dangerfield does not appear to have submitted any report on his work in Kumaon, and again the Governor-General was disappointed.

Captain J. D. Herbert: Geological Surveyor of the Himalaya Mountains, 1823-1829

The fourth of these early geologists was Captain J. D. Herbert, Bombay Native Infantry, who succeeded Capt. Dangerfield in 1825 as 'Geological Surveyor of the Himalya Mountain'[2]. Prior to Dangerfield's arrival in Kumaon, Lieut. Herbert had been working on the 'Gurhwall Survey' with Capt. Hodgson, who later, as Surveyor-General, writes (27.9.1821)[3]:

> 'On the Gurhwall Survey also, Lt. Herbert and myself directed some notices to the subject (i.e. the Kamaon Mountains); but since I left the Mountains that officer has made a very extensive and valuable collection of the Minerals, Fossils, and Specimens of the various rocks, comparing the different chains of Mountains and he has also attained to a very respectable knowledge of the Theories of Geology and Geognosy from Books and I doubt not that his experience and the actual observations he has made will greatly tend to correct some of those Theories'.

Conseqently, Herbert's appointment to fill the vacancy caused by Dangerfield's resignation is not surprising. This duty was presumably directly under the Government of India as in the case of Dangerfield. It continued apparently until 1st November, 1829, when Captain Herbert, 'employed on a Geological Survey of the Himalaya Mountains', was reappointed to his former situation as Assistant to the Surveyor General of India[4]. In 1832, Herbert, then Deputy Surveyor General, entered the service of the King of Oudh to construct and superintend an Astronomical Observatory at Lucknow, and there Herbert died in 1833. As a result of his geological survey work in the Himalaya he wrote several papers that appeared between 1825 and 1831 in *Asiatick Researches* and *Gleanings in Science*. But his important paper was a 'Report of the Mineralogical Survey of the Himalaya Mountains lying between the rivers Sutlej and Kalee, illustrated by a Geological Map' published posthumously in 1842[5]. This work of Herbert is referred to by Medlicott and Blanford in the following words[6]:

> 'Indeed, the first attempt at official geological work in India was the mineralogical survey of this ground undertaken by Captain Herbert by order of the Governor General (Lord Hastings). The work was finished in 1825, but was not published till 1842, nine years after the death of Captain

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1 Bengal Despatches, Vol. 97, 4.8.24, page 483, para. 138.

2 Bengal Despatches, Vol. 97. p. 483

3 Board's Collections, Vol. 682. p. 421.

4 Bengal Despatches, Vol. 112, p. 422.

5 *J.A.S.B.* XI, Extra No. pp. i-(cl) xiii

6 "Manual of the Geology of India" pp. 609 (1879).

> Herbert. As the work of an accomplished man, fairly versed in the science of his day, Captain Herbert's report is of permanent interest for students of geology in India, as the best local illustration of the state of geology at that time'.

It will be noticed from the foregoing passages that in these early days of geology in India the terms mineralogist and geologist seem to have been used interchangeably. That is probably partly because of interest in the economic implications of the discovery of minerals of value to man. But there is another cause, which has been brought out by Professor Judd in his Anniversary address to the Geological Society of London in 1887. The subject of Judd's address was the past and present relations between Geology and the Mineralogical Sciences. The following quotation from this address is apposite here[1]:

> 'The geologists of this Society stand in no need of the reminder that "their father was a mineralogist". That little band of enthusiasts, who, just eighty years ago, constituted themselves the nucleus of the Geological Society of London were before all things mineralogists; and the initial object of the formation of the Society was a purely mineralogical one, that of securing the publication of Count Bournon's laborious treatise on the varied forms assumed by the crystals of calcspar'

In the early years of the Geological Society of London, the emphasis was on mineralogy and petrology. Later came the turn of stratigraphy and palaeontology.

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[1] *Proc. Geol. Soc.*, 1887 p. 31

CHAPTER III

PRELIMINARY PERIOD

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It has been shown in Chapter I that D. H. Williams was the first geologist to be engaged in England specifically for geological work in India, his title being Geological Surveyor to the East India Company. He arrived in Calcutta (presumably by sea) on the 4th February 1846, and reported for duty the following day.

It has also been recorded that from 1817 onwards several appointments were made in India for geological and mineralogical investigation; and that several civil, medical and military officers in the East India Company's employ had engaged in similar work in their spare time, sometimes for the purpose of promoting the economic development of the tracts for which they were responsible, but at other times apparently from the pure love of research. With so much sporadic work in geology being prosecuted without cost to the East India Company, it becomes a matter of interest to enquire what spurred the Company to make a special appointment of Geological Surveyor, an appointment that led ultimately to the formation of the Geological Survey of India.

The Coal Committee: 1837-1848

This enquiry brings us to the Coal Committee. In 1835, the subject of India's coal supplies for steamers for inland navigation was under consideration; this, and the need for coal in the Presidency of Bengal for general purposes, led to the formation of 'A Committee for the Investigation of the Coal and Mineral Resources of India'. This Committee, usually known as the Coal Committee, was formed as a result of a Resolution dated the 28th December, 1836, signed by H. T. Prinsep, as Secretary to the Government of Bengal. The original members were five in number and included the eminent scholar James Prinsep, Assay Master at the Mint, and Secretary of the Asiatic Society of Bengal. Dr. W. Bannister of the Madras Medical Service, one of the Members, acted as Secretary to the Committee until he returned to Madras in February 1837. In his place Dr. J. McClelland was appointed Junior Member and Secretary on the 24th March, 1837, a post that McClelland held until the completion of the Committee's labours in

1845. The personnel of the Committee gradually changed through these years, with McClelland and Lieut. Col. Forbes, Mint Master, one of the original members, providing the thread of continuity.

It is suitable to quote the final paragraph of the Resolution as showing the purpose for which the Committee was appointed:

> 'Preparatory to adopting any definite measures with this object in view[1], the Governor of Bengal resolves, that the gentlemen named in the margin shall be appointed a Committee, specifically to consider all the information on the subject now collected at the Presidency, and to recommend what further examinations or surveys shall be ordered for the purpose, enabling Government to decide as to the best means of procuring Coal applicable to the wants of steam navigation in the interior. The enquiries of the Committee will embrace as well as the locality of the different Mines of Coal explored, the descriptions of the Mineral, and whether it is found alone or with iron, lead or copper, or other useful metals in the vicinity of the mines, and likewise by what routes and at what expense in their improvement or construction it will be possible to bring the Coal to the banks of navigable rivers'.

The first report (or rather set of reports)[2] was presented to Lord Auckland as Governor of Bengal with a covering letter dated 18.10.1837, signed by all the members (now six) including McClelland. According to this letter:

> 'the chief subject of investigation contemplated in our nomination as a Committee' was
> 'the existence, extent and relative accessibility of the beds of mineral Coal in different parts of India and their immediate applicability to the increasing demands of the steam navigation of the Ganges and its tributaries'.

The letter ascribes to Dr. McClelland 'the sole merit of preparing the several able and laborious abstracts which are now submitted'. The covering letter also enumerates 'all the sites of coal at present known to exist on the continent of India'. The list includes not only the Bengal fields—Raniganj ('Damooda'), Rajmahal and Palamow—but also those of the Nerbuddah valley, Chanda and Wardha, the Mahanadi valley, Assam, Sylhet and Burma, some of the localities being known only from specimens. The reports accompanying this letter are numbered as Sections I to VIII, and are all by McClelland, except Section VII by Capt. Henderson, another member of the Committee, on the Assam coalfield, and Section III by James Prinsep containing a table of analyses of Indian coals made at the Calcutta Assay Office. These assays include in nearly every case the specific gravity of the coal. These reports are not confined

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1 The object in view appears to have been the combining of the results of the several enquiries made in the past 'for the definite purpose of showing where the endeavour to bring the coal resources of the interior into use can be prosecuted with most chance of ultimate success'.

2 'Reports of a Committee for investigating the Coal & Mineral Resources of India', pp. 1-94, Calcutta: G.H. Huttmann Bengal Military Orphan Press, 1838.

to the consideration of coal, but include (Section VI) an account of the 'General features of Central India with reference to the distribution of minerals', illustrated by a geological map of Upper India, summarising the work of previous investigation, and depicting the distribution of the following formations: primary rocks (Kumaon and Garhwal), granitic rocks (Rajputana, Behar and Assam), sandstone (Vindhyans, Gondwanas and Tertiary, according to present knowledge), amygdaloid and basalt (Deccan Trap, etc.), salt, limestone, coal, and alluvium. The report contains also notes on the iron-ore, on the carnelians of Cambay, and on the copper and lead of Rajputana.

Later reports of the Coal Committee were published in 1840, 1841, 1842 and 1846, all listed under McClelland's name in La Touche's Bibliography.

The final report, that for May 1945, published, in Calcutta in 1846, summarises the work of the Committee from the beginning, assembling all the data collected.

The report was reprinted under an Order by the House of Commons, 19th June, 1863. The reprint is described as a 'Copy of Dr. McClelland's Report on the Coal Fields of India' and runs to 160 foolscap pages[1].

This final report summarises all that was then known of the occurrence of coal in India and Burma, and brings the total of analyses of Indian coals up to 100. There are maps of several of the coalfields, and Map No. 2 shows the distribution of the 'coal formation' from Bengal to the Central Provinces. The report contains no mention of coal in the Jharia and Bokaro coalfields, but the coal formation is shown as extending where these are now known to lie[2].

From the text it is seen that coal was known to occur in the Daltonganj, Hutar and North Karanpura coalfields, in Sirguja, and Korba in Singarauli and Sohagpur, as well as in several localities in the Nerbudda Valley, also in Talcher and Hingoli.

From the accounts included in the report it is seen that the Committee had incurred expenditure on the examination and prospecting of coal deposits and on the taking of samples. But the Committee also encouraged production by private enterprise. During the period of the Committee's labours,

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1 The report for 1845 extends from page 89 to page 160, and is preceded by an Introduction by McClelland to the reports of the Committee for 1841 (pp.3-36), and by abstracts of the proceedings of the Committee from May, 1839 to April, 1842 (pp. 37-38, including appendices). There is a copy of this reprint in the Library of the Geological Society of London.

2 A curious feature of this report of the Coal Committee is the absence therefrom of any reference to the existence of coal in what we now term the Jharia coalfield, although it seems that coal was found in Jharia as early as 1814 by Mr. William Jones, and then apparently abandoned by him because the Damooda (Raniganj) coal was more accessible. See letter dated 20th June, 1814 to G. Dowdeswell, Chief Secretary to the Government of Bengal.

the still existing and highly successful Bengal Coal Company was formed (1845) to amalgamate various private enterprises in what is now known as the Raniganj coalfield.

Correspondance with Lyell and Murchison: 1841-1843

During the period covered by the Coal Committee, McClelland corresponded with Lyell and Murchison on the question of employing trained geologists in India to investigate the coal formations of the country[1].

Eventually, in a letter dated 16.6.1843 from the Coal Committee the correspondence with Lyell and Murchison was sent to the Government of Bengal with the recommendation that these two geologists

> 'be consulted as to the best course to be pursued in ascertaining with certainty the situations in which coal may be had in India, and the depth, extent and quality in which it occurs in each locality'.

This was followed by a letter dated 4.2.1843 from the Government of Bengal to the Government of India, who in turn wrote the following letter (Home Department Marine, No. 13 of 1843) dated 14th October, 1843, to the Court of Directors in London:

> 'We have the honour to submit the accompanying communication from the Government of Bengal respecting the best means of ascertaining, with precision, the hitherto undeveloped resources of the country in the production of coal.
>
> The papers which we transmit will explain to your Hon'ble Court the grounds on which the Hon'ble the Deputy Governor urges the expediency of adopting a system of scientific inquiry both with the view of securing success to such attempts as are made by Govt. and of promoting confidence among private speculators to embark in undertakings for obtaining coal, and in expressing our concurrence in the views and recommendations of His Honour, we beg to request that the selection of the Geologist to be sent out by your Hon'ble Court, may be left to Mr. Murchison, the President of the Geological Society of London'.

Appointment of Dr. H. Williams as Geological Surveyor to the East India Company

The reply to this letter dated 23rd December, 1845 is printed as Appendix I to this Chapter and records the appointment of Mr. D.H. Williams 'for the purpose of making a Geological Survey of those districts in which Coal Fields are situated'. Williams's appointment had been recommended by Sir Henry De la Beche, Director General of the Geological Survey of the United Kingdom.

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[1] See Sir Cyril Fox's article in *Nature*. p. 889, 27.12.1947. Sir Cyril has discovered in the Records Branch of the Home Department of the Government of Bengal, McClelland's correspondance with Lyell and Murchison, which shows how much we owe to McClelland's initiative in promoting the problem of the expert geological investigation of India's coal resources.

The Geological Survey of the United Kingdom (now the Geological Survey of Great Britain) is regarded as having started as an official organisation in 1835 when Treasury approval was obtained for defraying the additional expenses that would be incurred in colouring, geologically, Ordnance country maps[1]. Henry Thomas De la Beche (later Sir Henry), who had already been colouring, geologically, Ordnance maps from 1832 to 1835, largely at his own expense, but aided by an official grant, and whose activities had led to this development, was appropriately chosen to organise and direct the operations, and his original title was Director of the Ordnance Geological Survey[2].

D.H. Williams was recruited to this survey in 1839 and resigned therefrom in 1845 on his Indian appointment. Williams was De la Beche's earliest geological assistant, though Logan (later Sir William Logan) was associated in an honorary capacity with De la Beche from 1835 to 1842, when he went to Canada and initiated the Geological Survey of Canada. Williams had as his contemporaries not only Logan but also W.T. Aveline (1840) and A.C. Ramsay (later Sir Andrew Ramsay) (1841) and he must be regarded as having been 'born in the blue' geologically. Williams was engaged on the geological survey of the South Wales coalfield (*loc. cit.* p. 48) and perhaps those of Western England, which includes the Bristol area. Vertical sections of the coalfields of South Wales and Western England were published in 1844 and 1845 and it is recorded that the Vertical Sections of South Wales were[3] prepared by Logan, De la Beche and D.H. Williams, (*loc. cit.* p. 45).

The service and death of Williams : 1846-1848

As we have seen, David Hiram Williams arrived in Calcutta on the 4th February 1846. He stayed at Spence's Hotel and reported his arrival on the following day as Geologist appointed by the Court of Directors of the Honourable the East India Company to investigate the Coal districts of India (see Appendix III to this chapter). Hence his service dates from the 5th February, 1846.

Williams's original instructions[4] after arrival were to proceed to Shergotty (Shergati) and Burhee (Barhi), but on his suggestion he was first allowed to examine coal strata where they were already known to occur, namely in the vicinity of the Damodar and Adjai rivers. Two young men (students) from the Medical College, Calcutta, by name William J. Ellis and Alex. Thomas, were nominated to accompany Williams as Assistants. They were described as 'at present quite ignorant of geology', but as qualified as interpreters[5].

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1 Sir John Flett, 'The First Hundred Years of the Geological Survey of Great Britain'. pp. 23-25 (1937).

2 See De la Beche's 'Report on the Geology of Cornwall, Devonshire, and West Somerset, (1839). Also see F.J. North, *Trans. Cardiff, Naturalists Society*, LXV, p.97, (1932).

3 See also F.J. North, 'Further Chapters in the History of Geology in South Wales'. *Trans. Cardiff Naturalists Society*, LXVII, pp. 65-69, (1934), for information based. on letters of D.H. Williams.

4 Board's Collection, Vol. 2172, 1846-47, Collection 105277, No.62, p.1.

5 *Ibid.*, pp. 3-6.

Thomas was provided with a medicine chest. Their appointment was a temporary one on Rs. 100 each per mensem plus travelling expenses (8 annas a mile). A letter from the Government of Bengal to the Medical Board refers to Williams as 'appointed Surveyor of Coal Districts and Supt. of Coal Works in India'. (*Ibid.*, p. 21)

Williams must have marched to the field in early March, when the hot weather was about to begin. His first report from camp at Raniganj, is dated 31st March, 1846, and his first Progress Report, written at Spence's Hotel, is dated 10th August, 1946. During the following field season (1846-47) he continued his survey of the Damodar valley coalfields. The two medical students are not again mentioned[1] but an assistant named H.G. Haddon was engaged (8.12.1846) on Rs. 250 a month; and a year later, Williams in a letter to the Government of Bengal dated 25.12.47[2] announces the engagement of a Mr. Jones (F.M. Brady Jones) 'who is a surveyor and draftsman', at Rs. 350 a month. (Jones had formerly been a civil engineer in the employ of the East India Railway, then being surveyed, at a salary of Rs. 500). The same letter mentions that R.G. Haddon had completed his first year of service and that as he had been found to be a competent surveyor his pay should be increased to Rs. 350, i.e. to the same as that proposed for Jones. These proposals were not finally sanctioned by the Government of India until their letter of 28.7.48. Jones and Haddon are both called Assistant Surveyors; and from later papers it seems that Haddon having joined first was referred to as First Assistant Surveyor and Jones as Second Assistant Surveyor.

In his second full field season (1847-48), in the early part of 1848, Williams, on Government instructions, visited the Kymore range of hills to the west of the Son river to examine a reputed occurrence of coal near Dearee (Dehri), one included in the list of the occurrences of coal in the report of the Coal Commission[3]. The supposed coal proved to be black argillaceous shale in what we now call the Vindhyan system; this excursion gave Williams an opportunity to cross the Vindhyan formation at several points. The remainder of the field season was spent on a continuation of the survey of the Damodar Valley coalfields especially on what we now call the Bokaro, Ramgarh and Karanpura coalfields.

At the opening of his third field season (1848-49), Williams resumed work in the Karanpura (Hoharo) Coalfield but soon fell ill with jungle fever. He came into Hazaribagh and stayed at the Bungalow of Dr. Collum, Assistant Surgeon, on the 13th November 1848, and two days later died.

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[1] It will be seen later that Williams had attached to him a Sub Assistant Surgeon, Kully Nauth Moozumdar, appointed evidently for field duty.

[2] Board's Collection, Vol. 2325, Collection 121007.

[3] See Williams's 'Geological Report on the Kymore Mountains etc.,' p.4. In February 1848, Dr. J.D. Hooker joined Williams's camp, and visited the Son Valley in his company, and also the Kymore Hills. See Hooker's 'Himalayan Journals', I, pp. 7-59 (1854).

Dr. Collum,[1] in a letter dated 15.11.48, to Haddon as Senior Assistant Geological Surveyor, reports the decease

> 'this morning at 10 o'clock of Mr. Williams, and that he came in late to my Bungalow at Hazareebaugh on the evening of the 13th instant, suffering from low "jungly fever" contracted while on duty in the Coalfields, near Indrajurba.
>
> 'It would appear that deceased met with a severe accident about 12 days ago, by falling from an Elephant, and again from a precipice, while employed in surveying. Jungle fever ensued, continuing until this morning when he became insensible, and four hours afterwards expired'.

In a second letter of the same date, addressed to Haddon, Dr. Collum reports the death of Mr. Brady Jones,

> 'who expired in a palanquin about 10 o'clock this morning when proceeding enroute to this station from his camp in the jungles adjoining Cheprajugra'.

The Sub-Assistant Surgeon in charge of the medical duties of the survey was in attendance on Mr. Jones.

Thus, Williams and Jones both died at about 10 a.m. on the 15th November. Haddon, calling himself 'Assistant Surveyor', in a letter of the same date to the Under-Secretary Government of Bengal, reports the death of Williams and that he had 'as senior Assistant taken charge of the Office and Establishment'; and in a postscript he reports the death of Mr. Jones, 'the second Assistant'.

In a second letter[2] dated 25.11.1848 to the Govt. of Bengal, Haddon describing himself as 'in charge of the Geological Survey of India', reports that I 'upon the recommendation of the Sub-Assistant Surgeon, Kally Nauth Moozumdar, in medical charge of this Establishment' he had removed the whole of the people to a camp near Hazaribagh until he received the orders of Government. He reported much sickness in camp and also on the progress of the work done until Williams's death. He reports that much of the work done had already been plotted, and that on account of the death of Williams and Jones 'the work is of course incomplete', yet 'it conveys much useful information both geological and geographical'. He presumes that the Survey will not be continued and suggests that as soon as the people are able to march he should return with the camp to Calcutta and hand over stores to the Commissariat. He proposes himself to complete the rough plotting of results and to finish the fair maps to the extent of the Survey and thus prevent any loss accruing to Government. In this letter, Haddon mentions that Williams had remained out in camp late in the previous season, not returning to Hazaribagh until June 16th. Haddon's letter contains the passage:

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[1] Board's Collection, Vol. 2325, 1848-49 Collection 121006.

[2] Board's collections, Vol. 2325, 1848-49, Collection 121006.

'It will be seen by the date, on which the late Mr. Williams returned to Hazareebaugh in June last, that he remained in tents during some very heavy rains in discharge of his duty. Mr. Williams also was ill for some days before he went into the station for advice, but tho' nearly all his people were sick as well as himself, his extreme anxiety for the progress of the work induced him to stay out until unfortunately too late'.

To resume work in the jungle too soon after the rains is now known to be unwise. Haddon does not record how soon after the rains work was resumed, except that some field work was done during the end of October. Evidently, it was too soon for a man already infected with fever during the previous season, especially as the mosquito bite was not then known to be the cause of infection with malaria, so that no special precautions would be taken against this danger.

Dr. J. Mclelland Officiating Geological Surveyor: 1848-1850

Dr. McClelland, after hearing of the death of Williams, wrote a private (or demi-official)l etter, dated Bhowanipore 23rd December, 1848, to Mr. F.J. Halliday, Secretary to Government Home Department[1] ,

This letter, which is printed as Appendix II to this chapter, is important. It summarises the efforts of the Coal Committee, of which McClelland was Secretary, to secure the services of either Sir Charles Lyell or Sir Rodrick Murchison for a three-year period to make a general survey of conditions as in India 'for the purpose of directing the public mind to a new field of enquiry in India'. Apparently, the Court of Directors opened negotiations with Lyell, but these fell through due to some 'misunderstanding touching the expense', and a reference then to De la Beche led to Williams's selection instead.

McClelland evidently did not approve of this appointment, because Williams's experience was not wide enough and had been confined to coalfields in England (the Bristol coalfield is mentioned). What McClelland had not wanted was the appointment of one who would at once get down to details, as Williams did and start measuring thicknesses of coal seams, instead of making 'a general examination of the whole of the Coal districts of the Country' 'in order to determine their bearing and relations with the great coal districts of other parts of the world'[2]. It is seen that McClelland had already laid down a plan of operation by which either Lyell or Murchison 'would have been enabled in three seasons to have completed all that was requisite in order to give both a practical and popular direction to such enquiries in India.'

McClelland suggests that 'perhaps under the present aspect of public affairs the subject may be allowed to drop'. But if this is not to be done, he

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[1] & [2] Board's Collections, Vol. 2325, 1848-49, Collection 121006.

offers his own services for three years commencing from November 1849, i.e., a year later[1]. He would undertake to make in three years, the survey originally contemplated by the Coal Commission.

McClelland's offer was not accepted, and instead he was appointed forthwith to continue the work where Williams had left off, after finaing from R.G. Haddon, 'the Assistant Geological Surveyor', what were the results of the past season's work not yet reported upon by Williams[2]. The note continues:

> 'Meanwhile Mr. McClelland will be given clearly to understand that the general object of his deputation is to go on with the survey from the point where Mr. Williams left off in tracing the coal formation from the Rajmall Hills to the Sutpara range between the Nerbudda and the Taptee and combining with this pursuit the collection of such other information on the mineralogy, botany and zoology of the countries traversed as may be gathered by a scientific observer without abstracting his attention from the main object of his enquiry'.

These instructions were conveyed to McClelland in a letter dated the 4th of December 1848, and he joined the Establishment at Hazaribagh on the 18th December. Directing his attention to the Barakar Valley, instead of the Damodar, he promptly discovered the 'Curhurbalee' coalfield, now known as the Karharbari or Giridih coalfield, reporting the discovery in a letter of the 26th December. This small field contains the best coal in India. All geologists would like to make important discoveries as quickly as this !

From this field he made for the Rajmahal Hills, and surveyed a considerable tract of the Monghyr and Bhagalpur districts in addition. The result of this work were printed as the 'Report of the Geological Survey of India for the Season 1848-49', published in Calcutta by J.C. Sherriff, Military Orphan Press, 1850. The report of 92 pages is in quarto format and illustrated by a geological map on the scale of 4 miles to an inch, with maps on a larger scale of the Karharbari coalfield, and of a part of the Rajmahal Hills, and with numerous coloured geological sections. The two larger scale maps and one plate of sections are shown as drawn by R.G. Haddon, "1st Asstt. Geol. Survey", whilst six plates of coloured sections, and a vertical section of the coal seams are shown as drawn by Wm. Theobald, Junr. "2nd Asst. Geol. Survey". McClelland is shown as officiating Geological Surveyor, and is also the delineator of six plates of plant fossils.

The official titles of Haddon and Theobald appear to have been First and Second Assistants to the Geological Surveyor respectively. When McClelland was appointed to officiate as Geological Surveyor he was authorised

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1 By this criterion Williams was not the right man for the job; but it is necessary and fair here to emphasise that Williams, having been appointed, put his heart and life into the work, and his writings, meagre as they are, show that he regarded himself as starting the geological examination of an empire.

2 Board's Collections, Collection 121006; note by Sir T. H. Maddock, Deputy Governor of Bengal, dated 2.12.48

to recruit another assistant in the place of Brady Jones. But later, in a letter dated Fort William 19th May, 1849 from the Under-Secretary to the Government of India, addressed to the Under-Secretary to the Government of Bengal, sanction is conveyed

> 'to the proposed employment of Messers. Johnson and W. Theobald as Assistants to the Geological Surveyor, on a Salary of Rs. 100 each per Mensem, including travelling allowance consequent upon the death of Mr. Jones, attached to the Geological Survey,' by which arrangement a saving of Rupees 255 per Mensem will be effected'.

A copy of this letter was forwarded to the officiating Geological Surveyor on the 26th May, 1849. Nothing further is heard of Johnson, except that he died of fever in 1850 (C.R.Markham's 'A memoir on the Indian Surveys', P.302)

McClelland remained in charge of the Geological establishment until 1850 when, in a letter dated March 23rd 1850, in which he designated himself as 'Officiating superintendent, Geologcial Survey', he asked to be relieved of his geological duties[1]. When McClelland's charge of the Geological Survey ended on the 1st April 1850[2], Haddon was engaged 'on the survey and drainage of the swamps of Purneah', and was treated as on detached duty under the orders of the Civil authority, but he was to pass under the orders of the Deputy Surveyor General when this work was completed. The services of Theobald and Gomess were left with McClelland, (? to help him finish his report) until the 30th April, 1850. The geological establishment was placed temporarily, from this latter date, under the charge of the Deputy Governor General Captain Thuillier, where it remained dormant until the arrival in India of Thomas Oldham.

The Assistants to the Geological Surveyor : Haddon, Jones, Theobald. Gomess : 1846-1851

As the geological work was evidently put into cold storage until Oldham arrived it is of interest to enquire what happened meanwhile to the three assistants. Haddon, it will be seen above, had already been seconded for ordinary survey work in Purneah. Haddon seems never to have returned to the geological establishment, but was alive in 1855[3].

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[1] There is no record of any field work having been done by McClelland and his assistants during the field season of 1849-50.

[2] See letter dated 26th March, 1850 from the Government of Bengal (Marine Dept) to the Officiating Geological Surveyor.

[3] See India & Bengal Despatches, Vol. 97, 4th to 25th June, 1856, p.341. Paragraph 8 of Narrative, dated 29.9.1855, No.28 reads: 'An Action brought by Mr. R.G. Haddon against the East India Company on account of Salary and repayment for materials compromised for Rs. 8,000 and costs, on receipt of Court's Despatch No.37 of 1855, expressing an opinion favourable to Mr. Haddon's claim to increased salary while on special duty'. This conflicts with C.R. Markham's statement that Haddon died in 1851. (*loc. cit.*, p.302).

Oldham[1] describes Haddon as 'an excellent surveyor attached to Dr. McClelland's party in 1848-49', but does not refer to him as having worked subsequently with the Geological Survey.

Theobald remained with the Geological establishment under Capt. H.L. Thuillier, Deputy Surveyor-General, until he was appointed[2] 'a 2nd Assistant on a Salary of Rs. 300 a month for the purpose of conducting a Geological Examination of the Salt Range in the Punjab during the approaching cold season'. He was directed to report his arrival at Lahore to the Board of Administration. Theobald, in a letter dated Garden Reach, November 1st,1850, addressed to Capt. Thuillier, 'In charge Geological Survey of India', informs him of this appointment, and adds :

> 'With respect to Office letters records etc., all such have been under charge of Mr. A.O.B. Gomess. All the Chemicals, Instruments, etc. for which Dr. McClelland made me accountable have long since been returned to store and receipts for the same filed in the office'.

Theobald thus joined the Geological Survey of the Punjab, commenced in 1848 by Dr. Fleming (see later page).

On the termination of this latter survey in 1852, Theobald wrote to Oldham in a letter dated Pind Dadun Khan, November 6th, 1852, applying for a post in 'your survey', and says

> 'You are perhaps aware that I was on the Bengal Survey both under Mr. Wllliams[3], and Mr. McClelland, and should in all probability not have left it, but for the undercertainty which prevailed as to when you would arrive in the countiy'.

Theobald records in this letter that he was then engaged in excavating coal, and also that he was well acquainted with levelling (This refers to a proposal for a set of levels for the alignment of the Railway — presumably the East Indian Railway)

It is of interest to enquire whether any ofthese assistants,Haddon, Jones Theobald, or Gomess, were geologists at the time of appointment. The answer is, I think, No. They were appointed primarily to make topographical maps, but naturally acquired some knowledge of geology. Williams, in the two reports by him published posthumously, makes no reference to assistants; nor does McClelland in the report noticed above, though his sections and drawings

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1 *Mem. Geol. Surv. Ind.*, VIII, p.210, footnote.

2 Letter No. 1748 of 1850 dated Fort William, 30th October, 1850, from the Under Secy. to the Government of India direct to Theobald.

3 Although Theobald was not appointed to the geological establishment until after the death of Williams, yet he was a member of the party when Williams and Haddon travelled with Dr. J.D. Hooker in the latter's visit to theS on Valley in February, 1848, perhaps in an unofficial capacity. See Hooker's 'Himalayan Jorunals'. Vol I, and 31 (Williams), 21 (Haddon), and 37 (Theobald) (1854).

were delineated by Haddon and Theobald, as already noticed[1]. Also, as will be seen in the account of the work of the Punjab Geological Survey under Dr. Fleming to be noticed later, Fleming distinctly takes all the responsiblity for the geological work, but gives credit for the topographical work to Purdon and Theobald. It will be seen later that Theobald became a good geologist; and he must have already become versed in the science to some extent by the time he left the Punjab, otherwise he could not have written his 1854 paper on the geology of the Salt Range[2].

A.O.B. Gomess is shown on a list of the Geolgical Survey staff as an assistant from 1849-1857, but I have not come across any record of his activities except the statement in the letter dated 24th March, 1851 (see Appendix III of this chapter) showing that he was on detailed duty at Purneah with Haddon at the time of Oldham's arrival in India. Perhaps, in view of the distribution of responsibility recorded in Theobald's letter to Captain Thuillier mentioned above we may assume that Gomess may have been a clerical rather than a technical assistant[3].

Williams's geological work We must now note briefly on the geological work accomplished by Williams during his brief period of service in India—but little more than 2½ years. The results of his work are contained in two published reports. The first is entitled 'A Geological Report on the Damoodah Valley', and the author is described on title page as 'Late Geological Surveyor in the Service of the East-India Company'. The report was originally printed in London, by Order of the Court of Directors, by J. & H. Cox, 74 & 75 Great Queen Street, Lincolns-Inn Fields, 1850. (pp. 131, Octavo). 1850 is also the year of publication of McClelland's Report for 1848-49 noticed above, and it is not known which of the two reports was published earlier. Williams's report was, of course, written first and it is dated Camp Soong, 7th December, 1847, It was reprinted at the Bengal Military Orphan Press Calcutta, in 1853, in similar form[4].

It is of interest to quote here from the conclusion on page 106 of this report in which Williams, having given the facts and pointed out the analogy between this coalfield (the Raniganj Field) and those of the western world, regards it highly desirable that the report

'should assume more the character of a records of facts than teem with

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1 Theobald was not appointed until after McClelland had completed his field work, but was in time to participate in the draftsmanship of the Plates to the report. But see previous footnote.

2 *J.A.S.B.*, *XXIII*, pp. 651-676.

3 According to Markham's text *loc. cit*, p. 302 Gomess left the Survey in 1852 and was Commissioner of the Sundarbans in 1871.

4 The Library of the Geological Society of London contains a copy of each printing, the 1850 copy being marked as presented by the Directors of the East India Company, and the 1853 copy as presented by T. Oldham F.G.S., whom we must suppose caused this reprinting.

> hypothetical speculations. The propriety of adopting such a course, at the commencement of a geological survey of a large empire, is unquestionable'.

This passage shows that although Williams was appointed for the survey of coalfields, he had visions of what this would ultimately lead to, as it did under his successor.

Williams's second report, published in 1852 is entitled 'A Geological Report on the Kymore Mountains, the Ramghur Coal Fields and on the Manufacture of Iron, & c. & c,'. The author's description is the same as in the 1850 report, but without the word 'Late' and the hyphen to East India. It was printed in Calcutta by F. Carbery, Bengal Military Orphan Press, Octavo. 92 pp.

The report is prefaced by a sheet of explanation that the text represents reports found among the papers of the late Mr. Williams and that no alterations have been made in the manuscript except obvious clerical errors.

> 'The MS. has been corrected, and the printing of these Reports superintended, by Mr. Oldham, Superintendent of the Geological Survey of India'.

Also,

> 'the Map which accompanies the reports has been carefully reduced, all compiled from the original surveys made under Mr. Williams's direction at the time of the Geological Éxamination of the Country'.

This language suggests that the topography was done by Williams's assistants and the geology by Williams. On the map itself is the additional information that the Curhurbaree Coalfield has been added from the report of Dr. McClelland, 1848-49. The title of the map is 'Geological Map of the Bocahroh, Ramghar, and Hoharoo Coal Fields Bengal'. The scale is 4 miles to an inch. The Report really contains four sections dealing in turn with the Kymore Mountains (recording Williams's search for coal in the Vindhyans), the Ramgurh Coalfields, the Manufacture of Iron, and General Remarks. In the last section, Williams is seen to be puzzled by the absence of any formations between the old gneisses and schists and the coal measures, thus recognising what is one of the characteristic features of Peninsular India.

On pages 89 to 92, Williams discusses a point that was to become of great importance nearly a century later, namely the unfortunate results of the Permanent Settlement on mineral deposits if the Zamindars were to be allowed to assume the mineral rights. If Government had taken notice of this comment of Williams, methods of work in the present century would have been much easier to control, so as to prevent the avoidable loss of many millions of tons of coal; and Government would have been in receipt of a source of income from royalties on coal that would have paid continuously ever since for the cost of the Geological Survey of India (provided the royalties had gone to the central and not to the provincial government !).

In addition to these two published reports, we must mention an unpublished report to the Government of Bengal by Williams on his first season's work, dated Spence's Hotel, Calcutta, 10th August 1846 of which no copy has been in the possession of the Geological Survey of India. Sir Cyril Fox, who has seen this report, regards it as the most important that Williams ever wrote, and has made the following summary of the principal points therein.

1. The coal measures rest on metamorphic and crystalline rocks.

2. He recognised two groups of seams - 10 seams with 78 feet of coal about Raniganj and 14 seams with 62 feet of coal about Taldanga, or 24 seams with 140 feet of coal.

3. He mentions coal near Induhgarh, 4 miles south of Fitcoory bungalow, as the lowest measures of all with 5 seams having 30 to 40 feet of coal.

4. He presses the case for a railway to the Raniganj coalfield.

5. He complains of the Damudar river ghat monopoly which the Bengal Coal Co. have secured by force.

6. He strongly objects to the extraction of coal by working outcrops.

7. He points out the absence of limestone and to the trouble that will occur in iron ore smelting.

Later, on the 3rd May, 1847, Williams discovered the coal at Taldanga to be a good caking or coking coal, this being the earliest discovery of coking coal in India. In addition, if it be not accepted that William Jones discovered coal at Jharia in 1841, then the discovery of coal at Induhgarh which is on the Jharia coalfield[1] must be regarded as the first actual record of the Jharia Coalfield.

Williams's two published reports contain maps of what we now call the Raniganj, the Bokaro, and parts of the Ramghar and Karanpura (Hoharo) coalfields. The Jharia coalfield lies between the Raniganj and Bokaro fields. It seems strange that it should have escaped effective discovery by this time. It is true that the Jharia field was visited by William Jones in 1814 and that Williams noted coal near Induhgarh four miles south of the Fitcoory Bungalow on the Grand Trunk Road, as mentioned above. Nevertheless, the field remained unsurveyed and unknown. Mc Clelland, by refraining from resuming Williams's work in the Damoodar valley, lost the opportunity of realising the the existence of the Jharia field, and instead discovered the Karharbari (Giridih) field; and the map attached to his 1848-49 report, whilst incorporating

[1] This is Sir Cyril Fox's identification. I have not myself succeeded in finding Induhgarh on any of the published maps of this coalfield.

the north edge of Williams's mapping in the Bokaro and Raniganj coalfields leaves blank the part of the map where the Jharia field lies.

Geological Survey of the Punjub Salt Range; A. Fleming, 1841-1852

Whilst the Geological Surveyor to the East India Company (Williams and McClelland in succession) was at work in Bengal and Bihar, a rival Geological Survey was commencing in the Punjab, a survey that actually overlapped the continuous period of the Geological Survey of India under Oldham. The work in the Punjab opens with a report by Dr. Fleming, Assistant Surgeon, Bengal Native Infantry, on the Salt Range and on its coal and other minerals[1], recording work commenced on the 19th March, 1848. Next, William Purdon, in 1850-51, describing himself as in charge of the Geological Survey of the Punjab, reports, in a letter dated Noorpoor, 20th January 1851, to P. Mcliville, Secretary to the Board of Administration of the Affairs of the Punjab, giving accounts of the Salt Range salt, and of the Dandot and Kalabagh coal[2]. Later in the same season (end of February), Fleming takes over charge and submits a report headed[3] '1st Report, season 1850-51. Geological Survey of the Punjab Salt Range', and signs the report as 'In Charge of the Punjab Geological Survey'. The report is dated Camp Bukrala, April 30th, 1851. The survey was resumed on the 1st November of the same year, and Purdon and William Theobald are named as 1st and 2nd Assistants respectively, so that Fleming had benefitted by the stoppage of the work of the Geological Surveyor's department by securing the services of Theobald. The results of these labours are published as a 'Report on the Geological Structure and Mineral Wealth of the Salt Range in the Punjab[4].

From this report by Fleming it appears that the geological examination of the Range was 'executed entirely' by him, whilst for the accuracy of the map (he means of the topography) Purdon was alone responsible, though Purdon was aided by Theobald. The map is on the scale of 8 miles to an inch. The copying and colouring of Fleming's field maps was done by an Eurasian draftsman named Blaney, whilst the geological sections were drawn in camp by Theobald from rough sketches by Fleming. The report is dated 'Jhelum Punjab, September 12th, 1852'.

The geological formations shown in the map are Devonian, Carboniferous, Oolite, Eocene and Miocene. The term Devonian is applied to the lowest beds, and the 'red marl with gypsum and rock salt' found at the base is regarded as a part of the basal formation. Thus, Fleming had settled the modern controversy about the position of the saline series before it had arisen. The value of Fleming's work was recognised by Wynne when he came to survey the Salt Range on behalf of the Geological Survey of India in about 1878, and it is no exaggeration to say that Fleming's work must be regarded

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1 *J.A.S.B.*, XVIII, pt. 2, pp. 500-526, (1846).
2 Home Series Miscellaneous, Vol 761, p. 727.
3 *Ibid.*, pp 748-750
4 *J.A.S.B.*, XII, pp. 229-279, 333-365, 444-462, (1852).

as at least as good as that of Williams and McClelland as a preliminary to the regular work of the Geological Survey of India.

Summary: the Preliminary Period of the Geological Survey of India

We must now summarise our knowledge of the Preliminary Period discussed in this Chapter. We see that Williams came out as Geological Surveyor to the East India Company, and that he nowhere used the phrase 'Geological Survey of India' and does not appear to have regarded himself as a member of such a department. Haddon, his First Assistant, appears to have used the phrase in a letter written after Williams's death, though without any evident authority: and McClelland, officiating as Geological Surveyor after the death of Williams, used the term in the title of his report for 1848-49. There is no evidence that he had authority for this but the use of such a title was in consonance with the fact that several countries were initiating Geological Survey Departments.

The geological Establishement, to use the phrase then current, did not, however, include any trained geologist except the Geological Surveyor: and his Assistants were apparently not originally geologists, being used mainly for topographical purposes, though Theobald soon became a good geologist.

With the death of Williams and the termination of the appointment of his officiating successor, McClelland, the department was put into cold storage until a successor could be obtained. Two of the Assistants, Haddon and Gomess, went off to other work in Purneah, though officially still a part of the Establishment; and Theobald severed his connections therewith and joined the Punjab Geological Survey.

The fact that there was for a brief period a Punjab Geological Survey working under official cognisance suggests that the Establishment of the Geological Surveyor to the East India Company was not then officially regarded as the Geological Survey of India with comprehensive all-India scope for all geological problems, especially as this post of Geological Surveyor has been established specially for the study of coalfields.

Nevertheless, after the break referred to above Thomas Oldham came to India as Geological Surveyor to the East India Company in succession to Williams; and after the termination of the work of the Punjab Geological Survey there was no further rival to the establishment of a Geological Survey of India with responsibility for all geological problems.

It will be seen from a consideration of the foregoing points that it becomes suitable to regard the years 1846 to 1851 prior to the arrival of Oldham as a Preliminary Period to the establishment of a Continuous Geological Survey of India.

PART II

CONTINUOUS PERIOD

(1851-1876)

PART II-CONTINUOUS PERIOD : 1851-1876

CHAPTER IV

THE GEOLOGICAL SURVEY OF INDIA UNDER DR. THOMAS OLDHAM

I. The Five Years 1851 to 1856

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Introduction *Appointment of Thomas Oldham as Geological Surveyor to the East India Company :* After the death of Williams and the cessation of geological work by McClelland, geological work on the eastern or Bengal side of India lay dormant, awaiting the arrival of a new Geological Surveyor to the East India Company. Thomas Oldham was the man selected for this appointment, 'in succession to Mr. Williams'. Oldham was appointed on 28th November, 1850 and arrived in Calcutta on 4th March, 1851. Prior to his arrival he had had much useful experience. He was born in May, 1816, became Geological Assistant to Captain Portlock, Ordnance Survey (Ireland) in 1839, and local Director of the Geological Survey for Ireland in 1846. He was also appointed to the Chair of Geology in Dublin in 1845, and was President of the Geological Society, Dublin, in 1848, being elected a Fellow of the Royal Society of London in the same year. Thus when he arrived in India in 1851 he was nearly 35 years of age, well equipped with geological experience. His appointment was for five years with the title of Geological Surveyor to the East India Company, and, although he served until 1876, when he retired a little before reaching the age of 60, he appears to have continued to serve with periodic renewals of five-year contracts.

Although his official title was Geological Surveyor, yet that seems to have been a title personal to the post; for, following the lead started by McClelland he, at once described himself, in correspondence, as Superintendent

of Geological Survey of India, and was so addressed in official correspondence. It seems desirable here to emphasise that the title 'Superintendent' or 'Director of the Geological Survey of India' is not one superior to that of 'Geological Surveyor'. The head of the Survey of India still uses the grand title of Surveyor General, and does not call himself Director General of the Survey of India, as he might. Thomas Oldham was called Superintendent of the Geological Survey of India till he retired, and his successor H. B. Medlicott used the same title until 1885, when the designation was changed (15th August, 1885) to Director of the Geological Survey of India, a title that has continued to the present day[1]. Such a title is in conformity with custom in the Geological Surveys of the world: but the analogy of the Survey of India shows that for India an alternative title could have been 'Geological Surveyor-General'. Oldham's title of Geological Surveyor to the East India Company was, of course, automatically terminated in 1858 when the control of India was transferred from the East India Company to the Crown.

Tribute to Thomas Oldham on his retirement : We are now about to describe the growth of the Geological Survey of India under the control and guidance of a great man. To put Thomas Oldham into the correct perspective it seems suitable to quote here *in extenso* the brief tribute that appears in the *Records of the Geological Survey of India* (Vol. IX. p. 27) on 'The Retirement of Dr. Oldham'. This tribute is unsigned, but must be presumed to be from the pen of the man who succeeded Oldham, namely, H. B. Medlicott[2].

> 'This number of our Records would be sadly wanting without a word of grateful farewell to the man who has conducted the labours of the Geological Survey of India from their beginning until now. When Mr. Oldham came to India in 1851, the Geological Survey cannot be said to have existed. Some coal-viewers and improvised[3] geologists had made occasional reports to Government, but there was nothing that could be called an institution, either as to staff or abiding-place. Professor Oldham conferred at once upon his post the influence of a well-known name, and the experience he had for years acquired as Director of the Geological Survey of Ireland. With those guarantees, by personal address and energy, he quickly acquired the confidence of Government, and by its liberal support he was able rapidly to bring together an efficient body of working geologists, with and through whom he soon began to throw light upon the rocks of India. Of the value of his services, as exhibited in the publications of the Survey, Dr. Oldham has repeatedly received very high testimony from the scientific world. To appreciate fully what he has effected, one should have experience of the position, where every means, material and personal, had to be formed or imported; and further, one should see what is only known to those present, the very valuable library and the extensive collections brought together

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[1] The title was subsequently (since 1961) changed to 'Director General'

[2] H.B. Medlicott arrived in India in 1854 *i.e.* only three years after Oldham's arrival.

[3] Without intending to dissent from the full justice of this tribute, it is necessary to demur to this adjective 'improvised', meaning 'brought about suddenly', in its application to some of the geologists discussed in Chapters II and III, and particularly to Williams, whose appointment as already shown, is traceable to the lengthy deliberations of the Coal Committee.

by his care. Due honour paid to the intelligent liberality of the Government of India, it is to Dr. Oldham, whether as Superintendent of the Geological Survey or as President of the Asiatic Society of Bengal more than to any other man, that Calcutta owes the magnificient museum-building it can now boast of. All this he now leaves to his colleagues and successors. Failing health compels him to retire from the service and leave the country before he could give form and unity to his labours. Those who reap where he has sown should ever remember the great debt they owe to Dr. Oldham'.

Thomas Oldham died two years later. The foregoing note suggests that Oldham left India not because of any age limit—he was 60—but for failing health, and that otherwise he would have continued to serve in India; this indicates perhaps the value of employment on a series of contracts which enable the employer to continue to re-appoint a man as long as his services seem valuable, and irrespective of any age limit. The customary maximum age of retirement, now[1] that the services has become a pensionable one, is 55.

Four periods for purposes of discussion: In view of Thomas Oldham's long service as Superintendent of the Geological Surveyof India—a period of 25 years of steady growth, marked by successive increases of staff, by the establishment of a permanent headquarters in Calcutta with Office, Museum and Library, and by the successive inauguration of suitable publications to render available to Government and to the public the results of the researches of his department —it is convenient to divide his term of office into four periods for purposes of discussion, as follows:

1. 1851-1856
2. 1856-1861
3. 1861-1867
4. 1868-1876

This sub-division arises naturally from the first two periods of Oldham's agreements, and from the dates of inauguration of the various publications of the Department, as follows:

(a) The Memoirs of the Geological Survey of India, 1856
(b) The Annual Reports of the Geological Survey of India and of the Museum of Geology,[2] 1857
(c) The Palaeontologia Indica, 1861
(d) The Records of the Geological Survey of India, 1868

The Five Years : 1851-56 Soon after his arrival in Calcutta, Oldham was instructed by the Government of India, (Home Department Letter No. 290 dated the 21st March 1851), addressing him as Geological Surveyor, to work under the Government of Bengal.

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[1] Date of write-up.

[2] Only known from the Third Year 1858-59, published in 1859.

The letter No. 189 dated Fort William, the 24th March, 1851, from the Secretary to the Government of Bengal to Professor T. Oldham printed as Appendix I to this chapter, shows that the Establishment of his office at the time of his arrival consisted of Haddon and Gomess, both of whom had been detailed for civil duty at Purnea. In addition, there were, of course, some papers and records deposited with the Deputy Surveyor General[1]; but as is noted in the tribute quoted above, there was no institution or 'abiding-place'. The services of Haddon and Gomess were, however, available to Oldham should he require them for his proposed researches in the Sylhet Hills. There is no evidence that he ever took either Haddon or Gomess back into his office, but Gomess appears to have been a part of the Establishment of Geological Survey until 1852.

Although his own establishment was thus in cold storage at the time of his arrival, active geological work was in progress in the Geological Survey of the Salt Range (or of the Punjab) under Dr. Fleming and this continued until the spring of 1852, Fleming's final report being dated September 12th, 1852. Presumably, with the completion of this report and the arrival of Oldham it was considered unnecessary to continue with a separate geological organisation.

Among the records of Oldham's office were the papers of Williams, whose first report, that on the Damoodah Valley had already been published in London in 1850 by the East India Company. Oldham had this reprinted (1853) in Calcutta. In addition, he edited Williams's notes on his later work and the results thereof were published in Calcutta in 1852.

Staff In the letter of the 24th March, 1851 noticed above Oldham was asked to report upon the establishment he might think it necessary to employ. He was naturally not in a position to reply to this request until he had obtained some experience in India. But it will help to clarify the position if we list here the geologists added to his staff during the period of his first 5-years' agreement 1851-1856. They were as follows, in order of appointment:

1851	J. G. Medlicott (Dec. 1851)
1852	R. I. St. George
1853	W. Theobald (11.7.53)
1854	H. B. Medlicott (24.3.54)
1854-55	J. S. Kennedy
1855	W. T. Blanford (1.10.55)
1855	H. F. Blanford (1.10.55)

Concerning some of these geologists a few notes will be useful here.

J. G. Medlicott left the Geological Survey in July, 1862 (being then in charge of the Bengal party of the Survey) to become Inspector of Schools in the Educational Department in Bengal.

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[1] According to Sir Cyril Fox's investigations in Calcutta, McClelland appears to have left all the correspondence with the Government of Bengal.

R. I. St. George is mentioned, with J. G. Medlicott, as having during the rainy season of 1852, helped Oldham to complete the survey of a portion of the Khasi Hills (*Mem. Geol. Surv. Ind.*, I,p. 99), and also as having worked in the Rajmahal Hills (? in 1853-54: *Mem. Geol. Surv. Ind.*, II p. 307, 1860). He is there described as 'at that time attached to the Geological Survey of India'. Soon after he was transferred to the East Indian Railway as engineer (December, 1853)[1].

William Theobald, when his work with Dr. Fleming in the Salt Range came to an end, wrote to Oldham for an appointment in the Geological Survey and was appointed 3rd Assistant in the Geological Survey, joining the Department at Darjeeling on the 11th July 1853, travelling there from Jhelum in the Punjab. His application for travelling expenses incurred on the journey (Rs. 714, a heavy sum in those days) was rejected by the Government of Bengal in a letter dated 28.7.1853 to 'The Superintendent of the Geological Survey'. This decision indicates that Theobald was not regarded as on transfer from one Government appointment to another, and that his service with the Geological Survey of India dates from 1853, and not from the year (1949) in which he had worked as an Assistant under Dr. McClelland.

John S. Kennedy is not included in the list of officers of which there ary records in the Geological Survey office in Calcutta, but he is mentioned bt Thomas Oldham as 'a young gentleman of much promise, but who had jus arrived in the country, and was quite untrained'. He was sent in the field season of 1854-55 to help the Medlicott brothers in their work in the Nerbudda district. During the following field season Kennedy was taken ill and died. (*Mem.*, II, pp. 97, 98).

H. B. Medlicott, who was a graduate of Trinity College, Dublin, had distinguished himself in the Engineering School of Dublin University, and had been appointed to the Geological Survey of the United Kingdom in October 1851 under De la Beche. Whilst Medlicott was on his way to India in the spring of 1854, the need for a Professor of Economic Geology at the Thomason College of Civil Engineering, Roorkee, had been brought to the notice of the Court of Directors of the east India Company, and De la Beche recommended that Medlicott should be appointed to this post[2].

Consequently, shortly after his arival in India, and after some discussion as to terms, Medlicott was lent to Roorkee (15th August, 1854) where he served for several years, rejoining the Geological Survey of India on 1st October, 1862. Nevertheless, whilst officially at Roorkee Medlicott was often available to help the department in the field as will be seen. Eventually, of course, he succeeded Oldham as Superintendent.

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1 C.R. Markham's 'A memoir on the Indian Surveys' p. 303., (1871).

2 Board's Collections, Vol. 2541, 1853-1854. Coll. 148, 134.

Of the Blanford brothers only the older, W. T. Blandford remained with the Department until he retired (in 1882), after a career of unrivalled lustre and usefulness to India, both as a geologist and as a zoologist.

The younger brother, H. F. Blanford left the Department in 1861 and was later appointed Professor of Physics at the Presidency College, Calcutta; from 1867-74 he was Meteorological Reporter to the Government of Bengal, and from 1874 to 1888 he was Meteorological Reporter to the Government of India, being the first occupant of that post. That the first official Meteorological Reporter in India should have been a geologist is peculiarly appropriate in view of the fact that the atmosphere is but the outer of the three envelopes of the earth, gaseous, liquid and solid, that constitute the earth's crust: meteorology being fundamentally a branch of geology that for administrative convenience is studied separately.

Of this initial team of geologists, as we may call it, Oldham and the two Medlicotts came from Trinity College, Dublin and the two Blanfords from the Royal School of Mines, London. For many years these two educational institutions were destined to provide first class geologists to India. It is of interest to note also that when he arrived in this country, Oldham was already a Fellow of the Royal Society of London, and that H. B. Medlicott and the two Blanfords all later received the same distinction. This initial team was evidently a very strong one.

At this time the nomenclature of the officers was a simple one. Oldham was Geological Surveyor, and the others were all Assistants. They were apparently numbered in order, judging from Theobald, who was appointed 3rd Assistant. The correspondence of those days shows that the department was treated almost as a personal affair of the head thereof. Oldham was responsible for every thing that happened. The Assistants were for the purpose of helping Oldham in his plans for the geological survey of India.

We must now see what Oldham accomplished during his first five years with the help of his accomplished and active team of young geologists.

Sylhet Hills

When he arrived in 1851, Oldham was, of course, alone until the arrival of J. G. Medlicott either late in the same year or early in 1852. Oldham's first task was already indicated to him (see Appendix I), namely to proceed to the Sylhet Hills. Accordingly he spent the monsoon period of 1851 in surveying the Khasi Hills, with Cherrapunji as his base, returning there for the rainy season of 1852, with J. G. Medlicott and St. George to help him. In the winter of 1851-52, Oldham appears to have visited the Damoodah Valley to study the iron-ore deposits, whilst in the winter of 1852-53, he worked in the Rajmahal Hills (with J. G. Medlicott). In 1853-54, the survey of these hills was continued by Medlicott and St. George.

Burma

In the autumn of 1854, the examination of the Rajmahal Hills being then nearly completed, Oldham, accompanied by Theobald, set off for the Tenasserim province of Burma; they also visited the lower part of the Irrawaddy valley. Oldham himself then accompanied Major Phayre on his celebrated visit to the Court of Ava. (*Mem.*

Geol. Surv. Ind., II, p. 97. Also 'Yule's Mission to the Court of Ava', Appendix A). This was between the second and third Burmese wars. Oldham then visited the Yenangyaung oilfield, and described the native methods of oil-winding. It was there that Oldham recognised the connection between anticlinal structure and the collection of oil, which he did in 1855 (see Pascoe, *Mem. Geol. Surv. Ind.*, XL, p. 55) being the first to do so[1].

Nerbudda district and the Satpuras

At the same time a party was formed for the survey of the Nerbudda district under the charge of J. G. Medlicott, with the temporary assistance of his brother lent from Roorkee, and also J. S. Kennedy. In forming this party Oldham was arranging for what the Court of Directors had long desired, namely the examination of the coal-bearing series in this part of India, coal being the principal objective there, as it had been in the Khasi Hills and Rajmahal Hills. But under Oldham this search for coal involved a systematic study of the conditions under which coal-bearing rocks occurred, and therefore the continuous geological survey of the country in which the coal lay. During the next season, 1855-56, J. G. Medlicott worked alone, except that Oldham himself paid him a visit at the end of 1855; whilst in his third and last season in this tract, 1856-57, Medlicott had the assistance of Theobald to devote special attention to the Nerbudda alluvium and the fossils it contained. In his survey of this large tract, Medlicott surveyed some 8,000 square miles geologically, of which he also made the original topographical survey of some 2,500 square miles (see *Mem.*, II, p. 99). In commenting on this work, Oldham makes some remarks that are worthy of quotation as they apply to so much of the early work of the officers of the Geological Survey of India:

> 'European Geologists seldom realize fully the difficulties which attend the steps of their brother labourers in this country. Districts without maps, without roads, without supplies, without inhabitants, meet you frequently. To go where you wish is often simply impossible, and you must only rest content to go where you can. The most malarious and deadly parts of the jungle are often those which give the best, or perhaps the only sections visible. Seldom is it possible to return to the same place a second time, to correct an error, or supply an omission. The most marked and prominent features of the country, to which you trust as landmarks to fix accurately your position, are not uncommonly sources of confusion and perplexity, as you find the same peak known by different names, from different sides, or by different people, a fact which you only discover after long and tedious cross-examination.'

During this survey, which included the portions of the Satpura Range to the south of the Nerbudda Valley, such as the Pachmarhi Hills, Medlicott recognised the principal sub-divisions of the coal-bearing series, to which in his Memoir 'On the Geological Structure of the Central portion of the Nerbudda District' (*Mem. Geol. Surv. Ind.*, II), published in

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[1] Mr. Percy Evans, Geologist to the Burma Oil Company, has attempted, without success, to trace to its source this event.

1860, he applies the names adopted by Oldham in 1856, namely, Talcher, Lower Damuda, Upper Damuda, Mahadevas, and Lameta. He also recognises (*loc. cit.*, p. 217) that there are three periods of trap intrusion:

> '1st. one prior to the oldest Talcheer, 2nd. one subsequent to the Lower Damudas and prior to the Mahadevas, and 3rd. the great Basaltic period when all the overlying trap of this country was poured out over the surface'.

The last is, of course, what we now call the Deccan Trap, of which there is an abundance of intrusive representatives in the Satpuras.

The Vindhyans

H. B. Medlicott, in his survey in this tract in 1854-55, crossed the Singrauli coalfield, and surveyed the country on the north side of the Nerbudda Valley, and thus laid the foundations of our knowledge of what we now call the Vindhyans. He established the three-fold division thereof, an p adopting the names proposed by Oldham in 1856, namely Bundair (Bhander), Rewah and Kymore (Kaimur), he called the underlying rocks the Sub-Kymores, now known as the Lower Vindhyans. In his Memoir 'On the Vindhyan rocks, and their associates in Bundelcund' (*Mem. Geol. Surv. Ind.*, II, pp. 1-95, 1860), presumably incorporating some later work, he recognises also the Bijawar series, and to the equivalent of the Sub-Kymores found to the north-west he applies the names of Semri and Tirohan, etc.

Talchir Coalfield

We must now turn to the work of the two Blanfords, who arrived in India in October, 1855. They were given the task, with the aid of Theobald, of surveying the Talchir coalfield in Orissa, during the field season of 1855-56. The results of this survey, completed apparently in one season, are given in a paper 'On the Geological Structure and Relations of the Talcheer Coal Field, in the District of Cuttack' (*Mem. Geol. Surv. Ind.*, I, pp. 33-88, 1859), this memoir being thus the first systematic study of Indian geology to be published by the Geological Survey of India. It is by all the three members of the party. This work contains a detailed description of the basal beds of the coal-bearing series (which we now term the Gondwana system), and a discussion of the origin thereof. By sheer process of elimination of possibilities, the authors, working in one of the hottest parts of India, decide in favour of floating or ground ice (p. 56) as the only theory that can satisfactorily explain all the observed phenomena, typified by the presence of boulders often of large size embedded in a matrix of fine silt. They propose the name "Talcheer Group" for this boulder bed and certain other beds overlying them separated by an unconformity from the higher 'Damoodah Group'. Similar boulder beds had been observed by other geologists in other coalfields (e.g. by Williams in the Bokaro coalfields: reference to his work is made). In this ascription of the formation of the Talchir beds to ice action, to

be confirmed later by the discovery elsewhere of facetted and scratched pebbles, and ice-scratched pavements, one of the foundation stones had been laid for the later conception of Gondwanaland as a great southern continent.

Nomenclature

In May, 1856, Oldham read an important paper before the Asiatic Society of Bengal on the classification of the rocks of Central India[1] resulting from the investigations of the Geological Survey. In this paper he introduces the terms Damuda and Mahadeva proposed by himself, and Talcheer proposed by the Blanfords[2] for the principal divisions of the coal-bearing series, and the term Vindhyan with Bhander, Rewah, and Kaimur (Kymore) for the three divisions thereof for the great sedimentary system of Central India shown, as a result of H. B. Medlicott's researches, to be an older and quite separate system from the coal-bearing series (not to be called the Gondwana system until 1872). Medlicott had also proposed the term Sub-Kymore for the rocks below the Kaimur series in the Son Valley, afterwards to be known as the Lower Vindhyans.

Thus, in this remarkable first five years of Oldham's regime this small band of geologists had recognised and named the principal divisions of the Vindhyan system, and of the coal-bearing series, and had also clearly separated the two systems one from the other, thus dispersing the clouds of confusion that had so perplexed the earlier geologists, due to the existence of sandstones and shales in both systems. Further, the origin of the Talchirs as due to ice action had been recognised, one of the factors to lead later to the conception of Gondwanaland. Finally, Oldham himself seems to have shown the connection between oil accumulation and anticlinal structure. We may also note here that all this work, except that in Burma, related to the part of India to be recognised later as a part of Gondwanaland. Also it seems necessary to emphasise that however unorganised the department may have been prior to 1856, it was already a very healthy infant by 1856 ! In fact, has there been a later five years in the history of the department when so many discoveries of fundamental importance were made ?

Oldham's proposed plan of survey, 1852

We must now revert to the request (letter of 24.3.51) of the Government of Bengal that Oldham should report on the establishment he should think it necessary to employ (Appendix I to Chapter IV). This he did in a letter No. 10 dated April 3rd., 1851 from himself as Superintendent of the Geological Survey. This letter, written so soon after Oldham's arrival, I have not seen; but his letter No. 130 dated Cherra Poonjee 2nd September, 1852 (see Appendix II to this Chapter) refers to the former and contains Oldham's

1. *J.A.S.B.*, XXV, pp. 249-255, (1856).

2. *Mem. Geol. Surv. Ind.*, II, p. 310.

plans for conducting the survey. The first paragraph is of the greatest importance as it lays down clearly the duty of the Geological Survey of India as a department, and enunciates principles that apply to any Government sponsored geological survey department. It reads:

> 'The special object of Mr. Williams's appointment originally, would appear to have been a careful examination of the several coal fields of India, with a view of their being more extensively worked. But the subsequent despatches of the Hon'ble the Court of Directors as well as the constant reference of questions for investigation relating to the mineral resources of the Country generally, more especially since my own appointment, render it obvious, that our duty includes a general and systematic geological examination of the districts visited and a careful investigation of their mineral resources of every kind, whether coal or otherwise, and of the possibility of their profitable application in developing the industry, and so increasing the wealth of the country'.

After mentioning his own investigations into the possibility of manufacturing iron in India he puts forward two alternative plans of survey and asks for instructions on which to adopt. Thus:

> 'There appear to me two distinct plans which might be adopted. One in which the progress of the Geological Survey would successfully and continuously embrace the whole of the country, so that after a time a general Geological map could be published. And another, on which detached districts should be examined, to which attention might be directed by any special discoveries, or for any special object and thus a series of isolated maps, and reports on detached districts be prepared'.

> 'Undoubtedly, the former plan by which a steady continuous, and systematic examination of the whole country would be undertaken, is the one most likely to lead to sound practical results, (although in some cases not so immediately as the other system) and by which the most valuable additions to Geological science would be obtained. And unquestionably also, this is the plan which should be adopted in any country the topography of which was well known, and of which good maps existed. Unfortunately, however, such maps exist only for a portion of this Country, and some important Geological districts have not yet been surveyed'.

He then discusses the other possible method of detached investigations, and recommends that the two systems might be usefully combined. Should the second method be preferred, and the whole strength of the survey be directed to a single locality, then he mentions three separate districts of peculiar interest to the geologists, namely the country of Assam, the Tenasserim Provinces, and the districts adjoining the Nerbudda, all stated to contain deposits of great value and importance.

The later part of the letter discusses travelling expenses, tents, and transport, including elephants.

The decision taken on the alternatives discussed by Oldham will be seen from the following quotation from a despatch from the Court of Directors to the Government of Bengal[1]:

> 'We observe that at the suggestion of Professor Oldham you have sanctioned his conducting the Geological Survey in future on a continuous and regular plan, instead of selecting for examination isolated and often separated tracts of country. From Sikree Gully, in the neighbourhood of Rajmahal, where he was employed at the date of your letter, he was to proceed regularly to the westward, including in his Survey all the country South of the Ganges, as far as the published Revenue Survey Map or Maps of the Indian Atlas extend, that is to say to some distance beyond the Sutlej. Such a systematic course is no doubt in most respects preferable to the other, and we see no objection to its adoption, unless it would appear likely to occasion a much longer postponement of the Survey of the Coalfields of the Nerbudda Valley, to which we can scarcely attach too much importance, when we bear in mind the great expense and practical difficulty of supplying the Bombay Presidency with all their coal from Europe as at present. We infer, however, from a passage in Oldham's letter, that a cursory examination, sufficient for practical purposes, might be made of any detached district with respect to which geological information was immediately required, without seriously interrupting the progress of the main survey. If this inference be correct the Nerbudda District ought to be the earliest examined and we wish this to engage your earliest attention'.

It will be seen from an earlier section of this chapter that Oldham succeeded in carrying out the wishes of the Court of Directors as well as in arranging for systematic geological survey of continuous stretches of country. The method of combining continuous systematic survey with special examination of areas of immediate economic interest thus established by Thomas Oldham is the method that has been in vogue throughout the greater part of the subsequent career of the Geological Survey of India, so that Oldham finished his first five years of service with the foundations successfully laid of the methods by which the department was to operate, as well as with the foundation laid of the classification and nomenclature of the Vindhyan and the coal-bearing Gondwana systems.

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1. India and Bengal Despatches, Vol. 83, pp. 1161-1182, Despatch Bengal Marine Dept 9th Nov. (No. 28) 1853. p. 1174, para. 29.

CHAPTER V

THE GEOLOGICAL SURVEY OF INDIA UNDER DR. THOMAS OLDHAM (*Continued*)

II. The Five Years 1856 to 1861

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Oldham's proposals for the organisation of the Department, 1856

Towards the end of 1855, the Government of India in the Public Department in a letter dated 10th September (No.77), 1855 reported to the Court of Directors that they had received from 'Mr. T. Oldham, the Superintendent of the Geological Survey' an application to renew his engagement due to expire on the 5th March, 1856, but on an increased salary (Rs. 1,250 per mensum). India supported the application.[1] In reply, in a letter dated London 5th March, 1856, the Court of Directors[2] sanctioned 'the re-engagement of the services of Mr. Oldham, the 'Geological Surveyor' for a further period of five years, on a salary increase from Rs. 888 per mensum to Rs. 1,100 per mensum. The Court of Directors remark that they have not received reports of the progress of Mr. Oldham's labours 'so regularly as we could desire'. Consequently,

> 'We direct that in communicating his re-engagement you call on him to submit a general scheme on which the future investigations should be carried on and that, when a plan of operations shall have received your sanction, it should be adhered to with as little deviation as possible. We desire that a full report of his past labors, and any map he may have made, may be sent to us'.

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[1] India & Bengal Letters Received. Vol. 94, 1-30, Sept,, 1855

[2] India & Bengal Despatches. Vol. 95, 2nd Jan. to 28th March, 1856, pp. 1097-1103.

These views of the Court of Directors when conveyed to Oldham led to a spirited reply, to the justice of which the Government of India gave full support. This reply of Oldham is contained in two important letters, No. 68 and No. 69, both dated 31.5.1856, to C. Beadon, Secretary to the Government of India, Home Department[1] Letter No. 68, with its accompanying note, is printed as Appendix III to the chapter IV.

The note is on the organisation of the Geological Survey of India and is described in the covering letter as giving some consideration to 'a general and uniform plan on which I would propose that the operations should in future be carried out' 'with a few propositions for the improvement and extension of our establishment and of our labours'.

In this note, Oldham refers to the following points :-

1. His previous letter on the same subject dated the 2nd September, 1852 (No. 130) to the Secretary to the Government of Bengal.

2. He mentions that there are two series of maps. One is those of the Revenue Survey, on the scale of 1 inch to a mile, and lithographed, the stone being destroyed after striking off the requisite number of maps. The other is the Atlas of India on the scale of 1 inch to four miles, engraved on copper, with the originals carefully preserved. He proposes to adopt the Indian Atlas scale for the general basis of Geological examination and to use the larger scale only in limited districts.

3. He proposes to introduce Geological Survey publications in place of the then scattered publication, partly as Government Records, and partly in the *Journal of the Asiatic Society of Bengal* and elsewhere.

4. He says that a central office with Library and Museum is indispensable to the effective progress of the Geological Survey.

5. He had lost four Assistants; one by death and three by their accepting better appointments. None would have left if the prospects had been better. He proposes a salary of Rs. 300 p.m. during the two years probation and then annual increments of pay of Rs. 50 up to Rs. 600.

6. As Atlas Sheets existed for the whole of the southern portion of the Peninsula and for a considerable portion of the Bombay Presidency, he recommends the Survey being extended to Madras, which would require an addition to his staff of 3 or 4 Assistants.

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1 Board's Collections, Vol. 2662, Collection 176, 441, pp. 69-89 and 19-27 respectively.

In his second letter, No. 69 of the 31st May, 1956, printed as Appendix IV to the chapter IV, Oldham defends himself against the remarks of the Court of Directors quoted above. He is disappointed that the salary proposed for his second period of service, namely Rs. 1100 p.m. is less than that proposed by the Government of India (Lord Dalhousie's Government), and fears that the decision of the Court of Directors has been influenced by the impression that the operations of the Geological Survey may not have been carried out on a systematic and regular plan. He takes the opportunity to refer to his own recommendations of September, 1852, and says that the deviation from the original plan was made at the wish of the Court of Directors. He defends himself spiritedly and refers to the necessity of undertaking topographic as well as geological work in many districts. He mentions the Khasia- Jaintia Hills, the Nerbudda Valley, Pegu and Ava, and Tenasserim, where the original surveys (i.e. topographical) have been done by the geologists. Also that in Bengal the greater number of maps have been found to be so incorrect as to require improvement. He mentions also the absence of a library, of a museum and of a laboratory, so that they have been working with the same difficulty that would affect a tradesman without his tools or a physician without medicine. He mentions also the difficulty of securing properly trained assistants owing to the absence of prospects of advancement for them. He concludes by hoping that reconsideration will show to the Honourable Court of Directors that the defects of which they complain have not been the fault of the Geological Survey, and that the emoluments they have sanctioned are not commensurate with the duties, risks and responsibility imposed on the Geological Surveyor.

The Government of India, Home Department in their letter, No. 97 of 1856, dated 11th July, 1856[1] to the Court of Directors, strongly support Oldham's claim for a salary of Rs. 1,250 (proposed by Lord Dalhousie's Government), defend Oldham against the Court of Directors' adverse criticism, and say that Oldham is in no way responsible for defects of progress, and support all his proposals. The Government of India also refer to Oldham's letter of 2nd September, 1852 and his recommendations contained therein. It is clear from the correspondence that Lord Canning as Governor-General took a strong interest in the matter, and the Government of India on his initiative took action in anticipation of the concurrence of the Court of Directors, authorising Oldham to recruit 3 or 4 more assistants, and recommended that the maximum pay to which the two Senior Assistants may rise be fixed at Rs. 600 and of the others at Rs.500. This is apparently the first step in introducing grades amongst the Assistants. In addition, Oldham was directed to make all his reports to the Government of India in future and not to various offices.

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[1] *Ibid.*, Collection 176, 441, pp. 1-5B.

It was in this same year, 1856, that Lord Canning had become Governor-General of India. Quoting from Sir Clements Markham[1],

> 'Lord Canning really took an enlightened interest in geology, and on his arrival Dr. Oldham was able for the first time to commence a regular survey of the country. Lord Canning ordered that, unless under very special circumstances, the geological surveyors were to confine their labours to those parts of the country which had already been mapped, and steadily to proceed, as far as the map existed, over the country from east to west'.

He thus gave orders that the work was to be conducted in the manner that Oldham had advocated almost from the beginning. In addition,

> 'Dr. Oldham's staff was increased, the labours of the Survey were systematized, and the reports were ordered to be published in a uniform series'.

Oldham accordingly started providing annual reports on the progress of the work of the department. Copies of his reports for 1856-57 and 1857-58, which we must presume he wrote, do not now seem to exist, the first known report being that for 1858-59. This is entitled 'Annual Report of the Geological Survey of India, and of the Museum of Geology, Third year, 1858-59', whether he intended to mean this numbering to refer to the years of the issue of these reports or to the years of the existence of the Geological Survey of India as an organised department, is not stated. As he had, prior to this date, been describing himself as Superintendent of the Geological Survey of India, almost from his arrival in India, it seems likely that he meant Third Year of the issue of these reports.

This conclusion is, perhaps, confirmed by the first paragraph of the preface to Volume I of the *Memoirs of the Geological Survey of India*, published in 1859, which shows that Oldham regarded the Geological Survey of India as in existence before 1856, and which reads as follows:—

> 'When the Staff of the Geological Survey of India was increased in 1856, and its labours systematized, and extended to the Presidency of Madras, under the sanction of the Right Honourable the Governor-General of India in Council, it was also ordered that the reports on different districts examined geologically by its officers, should be published in one continuous and uniform series, not as previously in various journals, and in different forms. The present volume constitutes the first of the series'.

Hitherto the officers of the Geological Survey, having no publication of their own, had communicated papers principally to the Asiatic Society of Bengal in Calcutta, and to the *Madras Journal of Literature and Science*, whilst reports had also been published by the Government, the latter appear

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[1] 'A Memoir on The Indian Surveys', Chapter XII—The Geological Survey of India, pp. 145-169 (1871).

in La Touche's Bibliography as Selections from the Records of the Governments of Bengal, India and Burma, respectively. After the *Memoirs* had been inaugurated the Annual Reports were still published separately, and so continued until the initiation of the *Records of the Geological Survey of India* in 1868.

In addition, there was a dammed-up pool of results, much of which represented work done during the first five years of Oldham's service, available to start the *Memoirs* with the swing with which they burst on geological science in the first two volumes published in 1856-1859 and 1860, respectively.

Staff

It is of interest to mention the staff at Oldham's disposal for the second lustrum of his service. He entered this second period with J. G. Medlicott, Theobald and the Blanford brothers, and with H. B. Medlicott still at Roorkee, but available for field work at intervals.

During this second five years, as a result of the expansion sanctioned, he recruited the following additional officers, the total sanctioned strength being apparently one Geological Surveyor or Superintendent, and 11 Assistants with one Curator of the Museum:—

10.4.1856	Charles Aemilius Oldham
2.1857	William Kennett Loftus
2.3.1857	Walter Lindsay Willson
4.3.1857	J. S. Wilson
4.3.1857	William King
4.1857	J. Geoghegan
6.1857	Harry Child
28.9.1858	Robert Bruce Foote
12.2.1859[1]	Frederick Richmond Mallet[2]
12.2.1859	Ambrose Tween
1.10.1860	Richard Trench
1.10.1860	Frances Fedden

1 1.11.1858. India transferred from the East India Company to the Crown.

2 If F.R. Mallet's date of birth, 10th February, 1841, has been correctly given (Obituary Notice, *Records*, LIII, p. 171) then he joined the department at the unusually early age of 18. According to the Obituary Notice of his father, Robert Mallet, F.R.S. (*Q.J.G.S.*, XXXVIII, Proc. 54, 1882) the latter was helped by his son between the years of 1852 and 1858 in the preparation of his great Earthquake Catalogue and Seismic Map. Frederick Mallet was, then, aged 11 to 17 years when he was helping his father; and it is, therefore, not surprising that he was qualified for appointment to the Geological Survey of India at so young an age. Even so F. R. Mallet was 80 when he died (24th June, 1921).

These geologists were all on appointment termed Assistants. Two of them had been in Geological Survey employ before coming to India, namely W. L. Wilson, who had been on the staff of the Geological Survey of Ireland since 1845, and R. Trench, who had been on the staff of the Geological Survey of Great Britain since 1858. W. K. Loftus was also a man of experience, as he was aged 35 about when he joined the department, and during the years 1849 to 1852 had been geologist to the Turko-Persian Boundary Commission. He had studied under Sedgwick at Cambridge[1]. William King came from Queen's College, Galway, and Child, Fedden and Tween from the Royal School of Mines, London. Four of these Assistants died within a short time of their arrival in India; namely Geoghagan, who died of sunstroke in the Madras Presidency in April, 1858; Child, who died of cholera in Calcutta in June of the same year; Loftus, whose health had already been injured among the swamps of Assyria, and whose health failed entirely in India, and who died in 1859 on his passage homewards to England; and Trench who died of acute phthisis in the Upper Son Valley in May, 1861.

During the whole of this period, the nomenclature of the officers remained the same. They were all still called Assistants. But senior officers such as J. G. Medlicott and the two Blanfords were placed in charge of parties, a development in organisation that was to lead to the introduction of the term Deputy Superintendent in the next period (in 1862).

During the first field season 1856-57 of this lustrum, J. G. Medlicott and Theobald completed the survey of the Nerbudda district, whilst H.B. Medlicott surveyed Bundelkhand (see *Mem., Geol. Surv. Ind.*, II, pp. 1-95, 1860). What the Blanford brothers were doing at that time I haven't yet discovered.

In 1875, Thomas Oldham and J. G. Medlicott went to Europe on duty, and during this year and the first part of 1858, the Sepoy Mutiny interfered seriously with the possibility of field work in some parts; Theobald had a narrow escape from mutineers at Mhow and went to Bombay.[2]

Government of India transferred to the Crown, 1858

Under the Government of India Act of the 2nd August, 1858, the powers and property of the East India Company passed to the Crown, acting through a Secretary of State, and the India Office was formed in London. The transference of the Government of India to the Crown and the appointment of Lord Canning as the first Viceroy and Governor-General were announced by Royal Proclamation on the 1st November, 1858. At the same.

1 His Turko-Persian work is described in a memoir in the Q.J.G.S., XI, pp. 247 (1855 See also *Op. cit.*, X, p. 464 (1854). He had followed his Turko-Persian work by research in Mesopotamia, where he made brilliant antiquarian discoveries among the ruined cities of Assyria and Babylona. See Obituary Notice, *Q.J.G.S.*, XVI, p. xxviii (1860).

2 *Mem., Geol. Surv. Ind.* II p. 98.

time the head of the Geological Survey of India ceased to be Geological Surveyor to the East India Company, and was presumably henceforth Superintendent of the Geological Survey of India only.

Bankura, Midnapore and Orissa

In the field season of 1857-58 a geological examination was made of three districts of Bengal[1], namely Bankura, Midnapore and Orissa. Bankura was surveyed by C. Oldham, with parts of Midnapore and adjoining districts; the district of Midnapore by J. G. Medlicott and W. L. Willson ; and the province of Orissa, comprising the districts of Balasore, Cuttack and Puri by W. T. Blanford assisted by Harry Child[2]. The map on the scale of 1 inch to 8 miles published with this memoir still represents our knowledge of much of the country represented. Besides rocks of the crystalline basement (mainly metamorphic schists with granite) and the coal-bearing series of Talcher and Cuttack, by far the larger portion of the area depicted is occupied by alluvium and laterite, which are shown separately. In the same volume of the *Memoirs* (page 280-294), Blanford discusses the composition and origin of the laterite of Orissa, distinguishing between laterite and lithomarge, thereby entering the lists to discuss an essentially tropical rock the origin of which had already exercised many writers since Buchanan-Hamilton named it in 1807, and was destined to exercise many others for many decades to come[3].

Raniganj Coalfield

In the field season of 1858-59, when W. T. Blanford and W. L. Wilson were already engaged in Birbhum, they were asked to begin the detailed examination of the Raniganj coalfield. The work was resumed by Blanford alone in the next field season, 1859-60, and completed[4]. The results were published in Volume III, Part I, of the Memoirs in 1863.

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1 It is perhaps well to mention here that the term Bengal then meant the Presidency of Bengal, which then included Bihar and Orissa, and much of Upper India.

2 See *Mem. Geol. Surv. Ind.*, I, pp. 249-274, (1859).

3 Dr. W. T. Blanford evidently retained his interest in laterite throughout his life. I cannot help recalling here my attending at his house in Campden Hill, London, in 1902, in order to be interviewed for appointment to the Geological Survey of India. I was shown into his study, where I had the great privilege of meeting the man who, in my opinion, is the greatest geologist who ever worked in India, a man who was then a white-haired gentleman of great personal distinction. After a few preliminary enquiries Dr. Blanford took a piece of rock from the mantelpiece and asked if I knew what it was. After looking at it carefully I was compelled to say 'No'. He then told me it was laterite and asked if I knew what laterite was. My reply was that we had had it in our lectures at college (Royal College of Science), but that I had forgotten what it was. 'Never mind' said Dr. Blanford, 'You'll soon know all about it'. We then discussed his collection of recent land shells and shortly after I was appointed to the Geological Survey. When in 1911, a paper by me entitled 'What is laterite?' was published in the *Geological Magazine*, I regretted very much that Dr. Blanford was not still alive.

4 In 1858-59 Blanford had the assistance of F. R. Mallet and in the following season of A. Tween; but, they were both new and then untrained assistants.

This Memoir is one of our classics and describes in detail India's most important coalfield. It is illustrated by a geological map on the scale of one inch to a mile, the first to be published by the Geological Survey of India on this scale. In his discussion of the rocks of the Raniganj coalfield, Blanford recognises three groups, namely Talchir, Damuda, and Panchet, the latter being a new term proposed by him and accepted by Oldham. In addition, Blanford sub-divides the Damudas into three sections, namely Lower Damudas, Iron-stone Shales, and the Raniganj series. Oldham in his comments on these terms points out the unsuitability of the term Lower Damuda and proposes the term Barakar instead (*Mem. Geol. Surv. Ind.*, III, p. 211). Blanford divided his Panchet series into two, namely Upper and Lower, but the name is now restricted to the Lower division only, the upper division being regarded as belonging to what we now call the Upper Gondwanas. Thus arose some of the most important terms in what we now call the Gondwana system.

This Memoir also discusses in some detail the history of the development of the collieries in this field, describes their working, and contains a list of the collieries then open with their outputs for the three coal years ending September 30th, 1858-1860. The total number of collieries listed is 50, some of them being worked by organisations that still exist, such as the Bengal Coal Company, the East India Coal Company and Apcar & Co., with several collieries worked by Indian owners. These data constitute a part of India's first mineral statistics printed in the Geological Survey of India publications.[1] The coal assays included in Blanford's memoir were done by Tween, one of the recently recruited assistants. This memoir also describes the iron-ores of the iron-stone shales with assays by G. E. Evans, late Curator of the Geological Museum, Calcutta.

During this survey, Blanford discovered (1860) vertebrate remains in the Panchets. Tween was detailed to make a more detailed examination of, and collection from, the beds in which these remains were found, and the collections were sent to Professor T. H. Huxley in London; Huxley reported that the bones represented Labyrinthodont Amphibia and Dicynodont reptiles. Thomas Oldham discusses the age implications of these vertebrate remains and of the *Glossopteris* and other plant fossils found in the various members of the coal-bearing series of India, in a paper immediately following Blanford's memoir (III, pp. 127-213). As a result of comparison with the known age of beds carrying similar vertebrate remains in Europe and South Africa, and similar plant fossils in Australia, Oldham allots to the Panchets an age equivalent to that of the 'earliest portion of the great Mesozoic

[1] It will be seen from *Mem. Geol. Surv. Ind.*, VII, p. 131 (1869) that Oldham had in June, 1859 published 'the first attempt at a careful or detailed return of the amount of coal raised in India,' a return that related exclusively to the Raniganj coalfield, and that had been specially prepared as bearing on the very important question referred to Oldham regarding proposals for an extension of the then existing line of railway.

division' (p. 205), or about the same age as the Bunter and Keuper of Europe. The Damudas he equates to the Permian plus a considerable portion of the Upper Carboniferous. In spite of the attempt by some geologists of recent years to hoist not only the whole of the Damudas, but also the underlying Talchirs, into the Permian, it is still thought in India that the Talchirs, and perhaps the base of the Damudas, especially if the modern Karharbari stage be treated as part of them instead as of the Talchirs, are of Upper Carboniferous age. This definite assignment of what we now know as the Lower Gondwanas to the Trias, Permian and Upper Carboniferous, was a great change from the views of the older geologists who thought that the coals of the Damodar Valley were of Jurassic age[1].

Mineral Statistics

The article in *Memoirs*, III, following shortly on Blanford's Raniganj memoir, is entitled 'India. Mineral Statistics. I-Coal.', and is by Oldham and dated 1st June 1861. It includes the data of production of coal given in Blanford's memoir, with the addition of the data for the same three years for the Rajmahal Hills, the Karharbari and Palamau coalfields, the Khasia and Jaintia Hills, Singrauli and Rewah, and the Lynah Valley, Sind. The total output of coal for India as there given can be summarised thus:—

	1858	1859	1860
	Tons	Tons	Tons
Raniganj	217,136	324,754	304,094
Other localities	9,004	40,821	66,112
Total	226,140	365,575	370,206

The data were obtained from the proprietors of the various collieries[2].

Oldham had hoped to issue statistics of coal production annually but in the absence of suitable assistance that would be specially devoted to such enquiries he was not able to publish another statement until 1860 (see *Mem. Geol. Surv. Ind.*, VII, pp. 131-139), when he brought the coal statistics up to 1868. No further attempt at the regular publication of mineral statistics for India was made until Sir Thomas Holland became Director (see *Rec. Geol. Surv. Ind.*, XXXII, 1-1189, 1905). But data for coal and some other minerals are given in Ball's Economic Geology, published in 1861, and several later reports on mineral occurrences contain statistics of production of the mineral in question.

[1] See H. J. Carter, 'Geological Papers on Western India', p. 663 (1857). Even Williams thought that *Glossopteris* was a genus of oolitic age (*Mem. Geol. Surv. Ind.*, III, p. 13).

[2] A summary of these statistical data is also given on page 12 of the Annual Report of the Geological Survey of India, fifth year 1860-61, published in 186[illegible]. This was published before Memoirs, III, Pt. 1.

Bengal

Whilst W. T. Blandford was surveying the Raniganj coalfield, the survey of Bengal elsewhere continued under J. G. Medlicott. In 1859-60 Medlicott (aided by Mallet) and W. L. Willson[1] surveyed parts of the Monghyr district, Medlicott finishing the survey of the Kharakpur Hills, whilst Willson also made a preliminary examination of the Karharbari (Giridih) coalfield.

In the following season the Bengal party surveyed the Monghyr, Bihar and Gaya districts as far south as the northern edge of Chota Nagpur or Ramgarh. During these two seasons the party also examined the edge of the alluvial plains all the way from Burdwan *via* the Bhagalpur and Monghyr districts right round to the Bihar, Patna and Sahabad districts, including portions of Bhagalpur, Monghyr, Tirhut, Gorakhapur and Azamgarh, north of the Ganges. Much of this alluvial survey seems to have been done by Theobald.

In the same season, 1860-61, J. G. Medlicott resumed in Central India, working in Rewah State. This work had been in abeyance due to the disturbed nature of the country.

Lower and Outer Himalaya

H. B. Medlicott's survey of Bundelkhand and adjacent country of 1856-57 has already been mentioned. The original intention was that in the following seasons the survey should continue towards Delhi (*Mem. Geol. Surv. Ind.*, III, Pt. 2, p. 3), but in 1857 the Mutiny broke out, and 'for two successive seasons it was impossible to visit that part of the North-Western Provinces for the peaceful purposes of geology'. Consequently, attention was directed to the hills, and in the field seasons of 1859-60 and 1860-61 Medlicott surveyed a large tract in the lower and outer ranges of the Himalaya, and the Siwalik Hills, between the Ganges and the Ravi rivers. The results of this work were published as a classic memoir (III, Pt. 2, 1864) in which Medlicott laid the foundations of our knowledge of the geological structure and relations of this part of the Himalayan ranges, a memoir which is really the first of any consequence upon any portion of the Himalaya. The work was encouraged and rendered possible by the publication by the Surveyor General of a new map much better than that which had been available to Herbert in his mineralogical survey of this country some 20 years earlier. As a result of his survey Medlicott introduced the nomenclature of the Sub-Himalayan formations (Siwalik, Nahan and Sabathu, with its sub-divisions Kasauli, Dagshai and Sabathu) and of the Himalayan formations (Krol, Infra-Krol, Blini (Blaini) Infra-Blini and crystalline and granitoid rocks[2]), a nomenclature that with amplification is still current.

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1 The Annual Report for 1859-60 says 'Mr. Wilson'. That this stands for W. L. Willson and not J. G. Wilson is seen from the foot-note signed by T. Oldham to page 210 of *Mem.* VII.

2 *Loc. cit.*, p. 17 and legend of map.

The area surveyed extended sufficiently deep into the hills to include the Simla Hills, and parts of Kangra. Medlicott was much puzzled by the position in the Simla Hills, e.g. on Jacko and Jutogh Hills of more highly metamorphosed rocks overlying the less mätamorphosed. He was 'at first tempted to look for grand inversion of the strata' (*loc. cit.*) p. 36). He resisted this temptation, however, as did R. D. Oldham many years later in the same country, and as did Middlemiss in Garhawal, so that this puzzle was not solved until the present century by Pilgrim, West and Auden[1]. As will be seen from the title of his Memoir, Medlicott's work was directed more to the physical relations of these ranges than to their rich store of vertebrate fossils already so well-known from the labours, mainly between 1835 and 1845, of H. Falconer and P. T. Cautley, who were the discoverers of the Siwalik fauna, and whose fine work had been recognised by the joint presentation to them in 1837 of Wollaston medals of the Geological Society of London. Medlicott described the Blaini 'conglomerate', but did not realise that it was to be correlated with the Talchirs of Peninsular India. It was left to R. D. Oldham in 1887 (*Rec. Geol. Surv. Ind.*, XX, p. 144) to decide that this 'boulder-slate', as he preferred to call it, owed its formation to ice action, and was to be correlated with the Talchirs of the Peninsula. (*Rec. Geol. Surv. Ind.*, XXI. p. 142, 1888).

Madras Presidency: Nilgiri Hills

We must now turn our attention to the Madras Presidency. Work in Southern India was begun by H. F. Blanford in 1857, the campaign opening with an attack upon the Nilgiri Hills, with the assistance of C. A. Oldham, William King and H. Geoghagan, the two latter being newly appointed Assistants. This work was apparently done during the recess season of 1857[2], as it was completed by the end of the year. The results of this work appeared with remarkable celerity in Blanford's paper 'On the Geological Structure of the Nilgiri Hills (Madras)' in *Memoir* I, pp. 211-248 (1858). The accompanying geological map is a simple one showing mainly gneissose rocks, with a little alluvium, two trap dykes, and occasional overprinted words, e.g., 'compact hornblending (sic) gneiss', 'quartzo-felspathic' and 'kaolin'. Blanford insists that the rocks of the Nilgiris are not of plutonic origin but must be treated as metamorphic gneiss, the original nature of which is not in evidence. He described them as hornblendic, frequently with garnets and usually devoid of mica. He was writing in the pre-microscope days of petrology, and did not know that the supposed hornblende was hypesrthene, the presence of which was to lead to these gneissose rocks being later regarded as members of the charnockite series.

With the completion of the Nilgiri survey the attention of the whole

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[1] See L. L. Fermor, 'Obituary Notices of Fellows of the Royal Society', Vol. 4, Nov. 1944 for G. L. Pilgrim, and Vol. 5. Nov. 1945, for C. S. Middlemiss.

[1] It will be seen later that in the winter of 1856-57 H. F. Blanford acted temporarily as the first Curator of the new Museum of Geology in Calcutta.

party was transferred in January 1858 to the Trichinopoly and South Arcot districts, so important because of the marine Cretaceous rocks they were known to contain. This knowledge, dated from the discovery of Cretaceous fossils near Pondicherry and Viruddhachalam, in 1840[1] by Mr. C. T. Kaye, of the Madras Civil Service, with the subsequent collections made by him and Mr. Brooke Cunliffe, and the descriptions thereof by Professor E. Forbes[2], and Sir Philip Egerton[3] of the invertebrate and fossil fish respectively.

Cretaceous rocks of Southern India

The results of this survey, lasting to the field season of 1860, are given in H. F. Blanford's memoir 'On the Cretaceous and other rocks of the South Arcot and Trichinopoly Districts, Madras' (*Mem. Geol. Surv. Ind.*, IV, p. 1-217, 1862). As mentioned earlier, it will be seen that the geologists who participated in this survey included C. A. Oldham, W. King, and Geoghagan (who died from sustroke at the end of April, 1815 in the Trichinopoly district), all transferred from the Nilgiris. In addition, R. Bruce Foote joined the party in December, 1858. W. L. Willson was in charge of the party in the summer of 1858 whilst H. F. Blanford was in Calcutta studying the fossils collected. In addition, W. T. Blanford, after the close of the working season in Bengal, passed a couple of months at Trichinopoly in 1859. During this survey, the party mapped the Cretaceous beds of the two districts, the Cuddalore sandstones, the coastal alluvium, and a considerable tract of the gneissic country to the west, the whole forming a part of the Carnatic tract at the foot of the Eastern Ghats. H. E. Blanford's special favourite became the Cretaceous rocks and their fossils, whilst King and Foote began their systematic attack upon the older rocks of the Peninsula, an attack that was to continue for so many years, and was to cause one to associate their names jointly with the geology of Southern India, in the same manner as one couples the names of Peach and Horne with the North West Highlands of Scotland. It is in this Memoir that Blanford proposed the names Utatur (Ootatoor), Trichinopoly and Ariyalur (Arrialoor) for the divisions of the marine Cretaceous formations of this country now known to range from Cenomanian to Danian in age; and the term Cuddalore sandstone, now regarded as Upper Tertiary (Pliocene) in age. During this survey Charles Oldham found fossil plants of Rajmahal age near Utatur in the Trichinopoly district (*Mem. Geol. Surv.Ind.*, II, p. 323 and IV, p. 39), this providing the most southernly known extension in India of what we now term the Gandwana system. At the end of this work on the Cretaceous rocks H. F. Blanford was, at his own request, transferred to Calcutta so that he could study the magnificent series of fossils collected during the course of the survey. Charles Oldham was then placed in charge of the Madras Party.

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1 *Mad. Jour. Lit. Sci.*, XII, pp. 37-42 (1840).

2 *Geol. Trans. Ser.* 2, VII, pp. 97-174 (1845).

3 *Q.J.G.S.* pp. 79-81 (1844).

For some time Thomas Oldham had been making preparations on his own responsibility for a new publication containing plates illustrative of the organic remains of India; and he records in his Annual Report for 1860-61 (page 8) that the liberality of his Excellency the Governor General in Council had now rendered this possible. The new publication was intended to be supplementary to the *Memoirs* of the *Geological Survey of India*, and was entitled the *Palaeontologia Indica,* destined to become so famous to palaeontologists throughout the world. H. F. Blanford had the distinction of writing the first part, which appeared in 1861 as 'I. The Fossil Cephalopoda of the Cretaceous Rocks of Southern India, *Belemnitidae-Nautilidae*', pp. 1-40, with 25 plates. As already related, H. F. Blanford left the Geological Survey in 1861 for the chair of Physics at Presidency College, Calcutta. The description of 'The Cretaceous Fauna of Southern India' was continued later by Stoliczka in successive volumes from 1865 to 1873, and Blanford's paper became Part I of Volume I of Series I.

The two Assistants, R. Trench and F. Fedden, who arrived in October, 1860 represented an addition to the staff of two posts to enable a geological survey of the British territories in Burma to be undertaken. W. T. Blanford was selected to commence this work, with one of the new Assistants, namely Fedden. The only district in the Pegu Territory of which Revenue Survey Maps were then ready was Henzada, and consequently work was begun here.

Office Library, and Museum

When Williams arrived in India in 1846, he had, of course, no fixed headquarters, and consequently, when recessing from field work, he stayed where it was convenient either at Spence's Hotel, Calcutta, or at Hazaribagh. When McClelland was appointed to officiate as Geological Surveyor in the vacancy caused by the death of Williams he already had a base in Calcutta by virtue of his previous duties and presumably he continued to use this base. When he ceased to be Geological Survey in 1850 the geological establishment was put into cold storage with the Deputy Surveyor General in Calcutta, as already noted. Consequently, when Thomas Oldham arrived in 1851, there was no office at his disposal and all the records were kept in a single box at the Surveyor-General's office[1]. As a result of this the headquarters of the department was for some years wherever Thomas Oldham happened to be, *e.g.* at Cherrapunji or at Darjeeling, during the recess season from field work[2]. This explains why it is that Theobald joined the Geological Survey at Darjeeling. This peripatetic existence seems to have continued until 1855 when a house was taken by Government at No. 1, Hastings Street and fitted up as a Museum and Office for the department.

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1 Indian Museum Centenary Volume, p. 53.

2 In England also, at the commencement of the Geological Survey, the headquarters was the place where the Director (De la Beche) happened to be living, and it was not till 1840 that De la Beche was allowed to reside in London. See F. J. North, *Trans. Cardiff Nat.* Soc., LXVII., p. 82.

Museum of Economic Geology

The Asiatic Society of Bengal, founded as the Asiatick Society in 1784, had, however, been provided with a permanent house, that still occupied, at No. 1, Park Street, since 1808, and the Society had established its own Museum there. In 1835, the Government of India, encouraged by the opening up of the Raniganj coalfield, decided to found a Museum of Economic Geology. This was effected in 1840, and the collections were housed with the Asiatic Society, in consideration of which the Society received a small monthly grant from Government for the payment of a Curator. In 1841, a typical collection of minerals was brought from England by Captain Tremenheere, and placed in the charge of Mr. Henry Piddington, who was Curator of the Museum of Economic Geology. This collection remained in the premises of the Asiatic Society until 1856, by which time the house newly acquired at 1, Hastings Street had been adapted for Museum purposes.

Museum of Geology

The collection was then moved to Hastings Street and the Geological Museum was opened to the public on 1st January 1857[1]. These changes were a part of the organisation of the Geological Survey of 1856 for which Oldham was responsible: and from 1856 Oldham used the dual title of Superintendent of the Geological Survey of India and of the Museum of Geology, Calcutta, a designation which was altered in his Annual Report for the year 1863-64 to Superintendent, Geological Survey of India and Director of the Museum of Geology, Calcutta. Oldham signed his annual reports with this dual title until his retirement, the last such report by him being that for the year 1875[2] (*Rec. Geeol. Surv. Ind.*, IX., p. 6).

Henry Piddington

From the above we see that in 1855 the Geological Survey of India acquired a headquarters building at 1, Hastings Street and that in 1856 the Museum of Geology was established there under the control of the Geological Survey. It is of interest to enquire whether on the transfer of the Government geological collections housed in the Asiatic Society's premises, Henry Piddington, their Curator, and a Government servant, went with them and became for a brief period an officer of the Geological Survey in continuation of his Curatorial services dating from 1841.

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1 Only some 5½ years after the opening of the Museum of Practical Geology at Jermyn Street in London (12 May 1951).

2 See 'The Indian Museum, 1814-1914', pp. 51-60, for an account of the history and growth of the Geological Section of the Indian Museum. According to this Centenary Volume p. 53, a note on this new departure at Hastings Street was inserted in the first volume of the *Memoirs* of the Geological Survey. This note must have been on a loose sheet, as it is missing from my copy of this volume, and the Contents thereof makes no reference to its existence. But it has been reprinted on pages 54 to 57 of the Musium Centenary Volume. See also the 'Centenary Review of the Asiatic Society of Bengal. From 1784 to 1883': Part III.—*Natural Science*, by P. N. Bose, pp. 107-109.

When, in 1886, it was decided to make this transfer of collections to the new Museum of Geology in Hastings Street, Piddington was given the opportunity to continue as Curator. The proposal was that the Curator should receive the same salary as before (Rs. 250 p.m.) and have charge of the collections and of the office under the Director of the Museum (*i.e.*, Thomas Oldham), as well as assay ores and minerals submitted. To provide for the frequent absences of the Director from Calcutta, it was proposed that Piddngton should not only be under the orders of Oldham, but also subject to such superintendence from the Professor of Geology in the Presidency College as Mr. Oldham might determine. This apparently strange provision was made because it was then contemplated by Government that this new Museum should later be provided with accommodation in the contemplated new buildings for the University and College.

Piddington took strong objection to this latter proposal. He was prepared to serve under Oldham, but not under anyone else, and particularly under Professor Liebig (Professor of Natural History and Geology at Presidency College). Piddington had already some 30 years service to his credit, and Liebig was a much younger man, and presumably but recently appointed, and he had also not yet given any lectures on geology (and, as far as we know, he never did). Besides being Curator of the Museum of Economic Geology at No. 1, Park Street, Piddington was also Coroner of Calcutta in an honorary capacity. As such he was, as he pointed out to the Government of India, next to the Judges of the High Court in the scale of precedence, as well as holding a parliamentary appointment and not one under the East India Company. Consequently, he would lose much personal prestige by accepting a position subordinate in any way to a professor at the Presidency College. In fact, it is quite clear from the correspondence that Piddington would sooner have starved than agree to such a proposal.

In the new Museum of Geology, the Curator was to combine with his Curatorship of the geological and mineral collections the duty of analyst for minerals and ores, for which Piddington's past labours showed him to be well fitted. But Government were not prepared to offer him more than the Rs. 250 per mensum he had been receiving from them whilst in charge of their collections in the Museum of Economic Geology for so many years (through the budget grant of the Asiatic Society).

This combination of damage to social position, and inadequacy of proposed emoluments, in view of the increased duties, caused Piddington to decline to remain Curator after the transfer of collections: it is quite clear from the correspondence that the main factor in this decision was that of personal prestige. The allowance paid by the Government of India to the Asiatic Society was discontinued on the 31st August, 1856, and was henceforth paid instead into Dr. Oldham's grant. Piddington did not succeed in handing over the collections until September 5th, so that he was regarded as having carried out his duties until that date, and was instructed

to obtain his pay for the first five days of that month from Dr. Oldham. But we cannot, I think, regard Piddington as having been an officer of the Geological Survey of India even for these five days[1].

H. F. Blanford: First Curator

With Piddington's declining to continue as Curator, Thomas Oldham put upon H. F. Blanford the duty of arranging the collections in the new home, and in this Blanford was assisted by Theobald and C. Oldham. Blanford acted as Curator from the 1st December 1856[2], and was also placed in charge of the office of the Superintendent of the Geological Survey.

Oldham regularised this arrangement with a request[3] to Government to appoint Blanford as Curator in general charge of this Museum and also of the current duties of the Geological Survey office in Calcutta, with a pay of Rs. 250 as Curator, and Rs. 150 from the Geological Survey grant as in charge of the office[4].

Thus, we see that H.F. Blanford was in fact the first Curator of the Museum of Geology. But anyone perusing the correspondence with Piddington may think it a pity that it was not possible to come to some arrangement with the man who had been in charge of the collections for so many years, especially as in the end the Curator was never placed under the Professor of Geology at Presidency College, and the Museum of Geology was never transferred to the University. In La Touche's Bibliography, 81 notes and papers, many of them recording the results of chemical examination of mineral products, are attributed to Piddington.

Union of two lineages.

From the facts related above it is interesting to reflect that with the re-organisation of the Geological Survey of India in 1856 two lineages were combined: that which dated from

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1 See Board's Collections, Vol. 2722, Collection 197,420, for the correspondence concerning Piddington and the transfer of the collections to the new Museum of Geology. See also *J.A.S.B.*, XXVI, p. 68 (1857), for reference to this transfer, and to Piddington. The Society's accounts show that Piddington's salary was paid by them up till the end of September.

2 The correspondence between Government and Piddington did not terminate until 15.11.1856, when Piddington's resignation was accepted by Govenmernt.

3 In his letter to the Government of India, No. 109, dated 1.12.56, written from the Geological Survey Office, 1, Hastings Street, in which he makes this request, Oldham refers to Piddington's resignation and to the transfer of the Professor of Geology (presumably Liebig) to other duties, and mentions that the Lieutenant Governor of Bengal has announced within the last few days that he has appointed H. F. Blanford to deliver a course of lectures on geology in the Pressidency College.

4 This proposal was accepted by the Government of India in their letter Home Department, No. 13, of 1857, dated 12.2.1857, to the Court of Directors. India & Bengal Letters Received, Vol. III

the arrival of Williams in 1846 as Geological Surveyor to the East India Company and, after a break, was continued with Oldham's arrival in 1851 to burgeon into the Geological Survey of India; and the second lineage, starting with the foundation of the Museum of Geology by the Government of India in Calcutta in 1840, housed in the rooms of the Asiatic Society of Bengal, with Piddington as Curator: so that the Museum section of the Department has a more ancient origin than the Survey section.

CHAPTER VI

THE GEOLOGICAL SURVEY OF INDIA UNDER DR. THOMAS OLDHAM (*Continued*)

III. The Six Years 1861 to 1867

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In discussing the third period into which we have divided Thomas Oldham's service, we must note that in March 1861 he entered on his third agreement, having then completed two periods of service of five years each. This new agreement must have been with the Secretary of State for India instead of with the East India Company.

Staff

Thomas Oldham started this third period with the following Assistants:—J. G. Medlicott, W. Theobald, H.B. Medlicott (still at Roorkee) W.T. Blanford, H.F. Blanford, C.A. Oldham, W.L. Willson, S. King, R.B. Foote, F.E. Mallet, A. Tween, B. Trench and F. Fedden. Of these J.G. Medlicott left the Department towards the end of 1862 on transfer to the Education Department, Bengal, as Inspector of Schools: H.F. Blanford resigned in December, 1861, and was later appointed Professor of Physics at Presidencey College, Calcutta: and A. Tween died on the 27th May, 1861.

The loss of these two fine geologists, J.G. Medlicott and H.F. Blanford was severe one, and was presumably due in part to lack of attractive prospects within the Geological Survey.

With his resignation from the Geological Survey, J.G. Medlicott seems to have become lost to science. But H.F. Blanford, remaining in service as a meteorologist was elected F.R.S. in 1880, and also continued to take an interest in geology (see La Touche's Bibliography). He was the author of a well-known textbook 'Rudiments of Physical Geography for the use of Indian School's, that reached its 9th Edition in 1881[1].

Thomas Oldham went to Europe in the spring of 1862, and returned in November with 3 geologists. These, with others recruited during this period of 1861 to 1867 were as follows:-

15.11.1861	Charles Augustus Hacket
11.11.1862	Theodore W. Hughes
11.11.1862	Dr. Hugh Kane, M.D.
13.11.1862	Arthur Beavor Wynne
13.11.1862	Clement J. Wilkinson
1862	Dr. Ferdinand Stoliczka, Ph.D (as Palaeontologist.)
29.10.1864	Valentine Ball
1866	M. H. Ormsby

Of these recruits two had had previous geological survey experience. Wynne has served as an Assistant Geologist in the Geological Survey of Ireland from 1855 to 1862[2], whilst Stoliczka had served with the Geological Survey of the Austrian Empire[3]. Valentine Ball was one of three

1 First issued as 'Physical geology of India', 1873 and modified in the third edition to the above text.

2 On his retirement from the Geological Survey of India on medical certificate (11.4.1863), Wynne was reappointed to the Irish establishment as Resident Geologist, serving in this post from 1883 to 1890.

3 Annual Report, *Geol. Surv. Ind.*, 1864-65, p. 7.

able brothers in Dublin, the others being Sir Robert Ball, the astronomer, and the third Sir Charles Ball, Bart, a well-known surgeon. Hughes and Wilkinson were from the Royal School of Mines.

Of these new recruits Kane and Wilkinson failed to stand the climate and resigned for reasons of ill-health in March, 1864 and January, 1865 respectively; whilst Ormsby died in June, 1870 from the after effects of sunstroke.

Since, according to Thomas Oldham, the Establishment was brought to full strength in November 1862[1], it appears that this must have consisted of 16 Assistants, including the Palaeontologist. This was to be the maximum strength for the next 40 years[2].

Changes in the titles of the Assistants were introduced during this period, 1861-1867. In 1862, three senior posts of Deputy Superintendent were created, and on the 1st October, 1862, H.B. Medlicott became Deputy Superintendent for Bengal (later Bengal and the Upper Provinces); on the 13th November, 1862 W.T. Blanford became Deputy Superintendent for Bombay; whilst C. A. Oldham became Deputy Superintendent for Madras (exact date not discovered). In the creation of these posts recognition was given to what had long been a fact, that the work in various parts of India had to be placed in the charge and superintendence of senior officers, although this did not deter Dr. Oldham as Superintendent paying extended visits of inspection to parties and officers in the field. In fact, it is clear from Oldham's Annual Reports and his published papers that he kept a very close watch on all that was happening geologically in all parts of India and Burma, and made a practice of himself examining new discoveries and advances wherever this was possible. In addition, all proposals of new names for stratigraphical divisions and formations had to pass his scrutiny and received his approval before they could be officially adopted.

Judging from the activities of the respective Deputy Superintendents, the term Bengal and Upper Provinces covered most of the Northern India including the North-West Himalaya in one direction and Assam in the other, as well as parts of Central India and of the Central Provinces; whilst the terrain of the Deputy Superintendent for Bombay included Sind, Cutch, Gujarat, Berar and a part of the Central Provinces. The sphere of the Deputy Superintendent for Madras extended to Hyderabad and the Godavari valley.

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1 Annual Report *Geol. Surv. Ind.*, 1862-63, p. 1.

2 Indeed, when I joined the Department in 1902, the equivalent cadre was 12, consisting of 3 Superintendents, 4 Deputy Superintendents, and 4 Assistant Superintendents, with one Palaeontologist. In addition, there were two Mining Specialists, these occupying temporary posts.

The remaining members of the staff were still simply called Assistants; but on the 1st May, 1866 all the Assistants, including the Deputy Superintendents, were placed in grades, three in number, the distribution being apparently as follows:-

Grade I : H. B. Medlicott, W.T. Blanford and C.A. Oldham
Grade II : W. L. Willson, W. King and R. B. Foote
Grade III : Mallet, Fedden, Hacket, Hughes, Wynne and Ball with two vacancies.
Curator : Tween
Palaeontologist : Stoliczka.

Tween and Stoliczka were presumably also Grade III Assistants.

The Grade-I Assistants were normally all Deputy Superintendents, though the two terms were not necessarily synonymous. Thus, subsequently, King became a Deputy Superintendent (15.11.1868) whilst still a Grade II Assistant, and did not become a Grade I officer until the 21st April, 1875. On the other hand, Mallet became a Grade I Assistant (25.1.1883) before being made a Deputy Superintendent (11.4.1883). This means, probably, that the Grades decided the scale of pay, whilst the Deputy Superintendent's post was an administrative one that had to be filled by the most suitable man available (e.g. during the absence of the permanent incumbent on leave) irrespective of grade. In any case we see the origin of the phrase 'graded officer'.

Annual Reports During these six years 1861-62 to 1866-67, Thomas Oldham published six Annual Reports, 1861-62 (Sixth Year) to 1866-67 (Eleventh Year)[1]. As before, these were published separately. In 1867, it was decided to change from the official or financial year to the calendar year for the period of report; so that Oldham's Twelfth Annual Report was for the calendar year 1867 and thus overlaps the last three months of the report for 1866-67, and in fact, is mainly repetitive of work done during the field season of 1866-67. This twelfth Annual Report which is dated 31st March, 1868, was also published as the opening paper in Part I of the First Volume of the Records of the Geological Survey of India, issued in June 1868. In this reprint, as we must regard it, the title 'Twelfth Year' is of course, omitted, since, with its inclusion in the Records, the necessity for a separate title had disappeared.

Perhaps, this is a suitable point at which to comment on the period appropriate for Annual Reports. For reporting mineral statistics it is suitable and necessary to adhere to the calendar year; but for reporting

[1] Up till, and including the Report for the Seventh Year, 1862-63, these Reports were signed by Oldham as *Superintendent of the Geological Survey of India*. From the Eighth Year, 1863-64, the words 'and Director of the Geological Museum, Calcutta', were added.

the progress of geological field work the advantage is not so obvious, as it is the incidence of the seasons that decides the times suitable for field work. Thus the field season for much of Peninsular India is from October to April or May[1]. On the other hand, in the Himalaya, Kashmir, and other elevated tracts, the best season for field work is from March or April to October or November. The result is that, whatever period may be selected for the Annual Reports of the Department, the field season in some parts of India will overlap from one year to the next.

The calendar year adopted by Oldham for the first year (1867) to be reported in the Records was adhered to in the first 30 volumes of this series. When Mr. C. L. Griesbach, as Director, discontinued the issue of the Records it still remained necessary to publish Annual Reports on the work of the Department. These necessarily again became separate publications, so that we then reverted to the procedure from which Thomas Oldham had escaped with the institution of the Records. Griesbach also reverted to official years as the period of report! In addition, he changed the title from Annual Report to General Report. The principal result, however, was that as he had abolished the Records there was no longer any suitable place for the publication of the shorter papers of the officers of the Department; so that those that could not be squeezed into the Memoirs had either to be withheld, or to be included with the Director's Report as Progress Report, as was done, for example, in the General Report for 1899-1900, in which Part III containing these Progress Reports runs to 181 pages.

Mr. T. H. Holland (later Sir Thomas), on becoming Director, in 1903, was compelled to follow Griesbach's plan for one report, namely 1902-03. Then he reinstituted the Records of the Geological Survey of India with Volume XXXI, 1904, and reverted to the calendar year for the Director's Annual Reports ; but he retained the designation 'General Report', by which these reports have been known ever since. These General Reports were published continuously up to that by Dr. Heron for the year 1938. The issue of such reports, either Annual or General, was discontinued by Dr. Fox (now Sir Cyril), but has been resumed by Dr. West in Volume 78 of the Records, that for the year 1939. Thus there is a hiatus of seven years during which no reports on the work of the Geological Survey of India have been published[2]. This is, of course, partly attributable to the upset to India's economy caused by the recent war, when a part of the effects and collections of the Geological Survey were evacuated from Calcutta to a safer part of India, and partly to the resultant scarcity of paper.

The Bengal Party We must now discuss the work of the Department during the period 1861 to 1867.

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[1] According to the Standing Orders of the Geological Survey of India formerly in force, the field season lasts from October 15th to April 15th.

[2] These were subsequently published all together as volume 79—Editor.

In 1861 J. G. Medlicott was still in charge of the Bengal Party, but as a result of his resignation from the Geological Survey on his promotion to be Inspector of Schools, Bengal, his brother, H.B. Medlicott, reverting to the Geological Survey from his Professorship at Roorkee, took charge of this party on the 1st October, 1862, with the title of Deputy Superintendent then first introduced. This party included Willson, Mallet, Hacket and the two newly appointed Assistants, Kane and Hughes, with later Ball and Ormsby.

Bengal and Bihar : During these years, H. B. Medlicott as Deputy Superintendent spent much of his time on general reconnaissance preparing the way for systematic work by members of his party, or co-ordinating the results of their labours. Thus in 1863-64, Medlicott devoted his attention to closing the gap between Bengal (in its broad sense) with the ground already surveyed in Central India and the Sone Valley; and in pursuance of this he also made a rapid inspection of the slaty rocks from the Kharakpur Hills westward to the Rajgir Hills comparing these rocks and the associated quartzites with similar rocks in the Sone Valley and confirming their identity[1]. Thomas Oldham also took part in this final revision.

Meanwhile, the routine surveys in Bihar were being continued by the Assistants. Thus W. L. Willson during the four seasons 1861-62 to 1865-66 continued the geological survey of districts of Bihar to the north of the Grand Trunk Road, mainly in Hazaribagh, Gaya and Monghyr.

Coalfields of the Damodar Valley : In 1863-64 Kane and Hughes were sent to make a detailed survey of the Jharia Coalfield. Soon, however, as Kane fell ill with congestion of the liver a few weeks after taking the field, this survey devolved on Hughes alone. The results of his work are contained in his Memoir on 'The Jherria Coal-field' (*Mem. Geol. Surv. Ind.*, V, pp. 227-336, 1866), illustrated by a geological map on the scale of one inch to a mile. This marked the beginning of Hughes's long series of surveys of Indian coalfields, in which he became a specialist, resulting in the publication during his service of no less than nine Memoirs, apart from articles in the Records discussing various problems on the economics of coal in India, including the results of borings and other prospecting operations conducted by him in India and in Tenasserim in Burma.

In 1864-65 and 1865-66 Hughes surveyed the Bokaro and Ramgarh coalfields, and in addition revised his Jharia map under Thomas Oldham's

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[1] See Medlicott's 'Sketch of the Metamorphic Rocks of Bengal' *Rec. Geol. Surv. Ind.*, II, pp. 40-45, (1869), for a concentrated account of this work in which, recalling his examination of the Bijawars in Bundelkhand, he treats at least a part of these Bengal rocks as infra-Bijawars. In this connection see also *Mem. Geol. Surv. Ind.*, LXII, p. 145, foot-note (1933). On the 1931 edition of the Geological Map of India, these Bihar rocks and their supposed Sone Valley equivalents have been given the Dharwarain colour.

own instruction. Ball worked partly with Hughes in this work and partly by himself. The result of these joint labours was a memoir on the Bokaro field by Hughes (*Mem. Geol. Surv. Ind.*, IV, pp. 39-108, 1867) and on the Ramgarh field by Ball (*op. cit.*, pp. 109-135, 1867). In addition, Hughes made a reconnaissance of the coalfields stretching westwards to Palamau and the Sone. The provision of new topographical maps of a part of the Raniganj coalfield made desirable also the transfer to these improved maps of Blanford's geologcial boundaries. This was done by Ball and Fedden in 1865-66.

In 1866-67, Hughes examined the Karanpura or Bokaro coalfield, and also the South Karanpura field discovered by Ball in 1865; and both coalfields are described by Hughes in *Mem. Geol. Surv. Ind.*, VII, pp. 285-342, (1871).

As Hughes remarks :-

> 'The description in this Memoir of the Karanpura coalfields, brings to an end the history of the mineral wealth of the Damuda Valley, in connection with its coal and iron-bearing deposits, which was commenced by the issue of the report on the Raniganj coalfield, and systematically continued in those of the Jherria, the Bokaro and the Ramgarh fields'.

The coalfields on the westward continuation of the Damodar Valley line of strike (Aurunga, Huttar and Daltonganj) lie in the basin of the North Koel river and its tributaries, draining northwards to the Sone river.

It is convenient to mention here that in the two following field seasons (1867-68 and 1868-69), Hughes revised the boundaries of the Karharbari (Giridih) coalfield on better maps (An. Rep. for 1868, *Rec. Geol. Surv. Ind.*, II. p. 28) and surveyed the Palamow coalfield, which he renamed the Daltonganj coalfield (*Mem. Geol. Surv. Ind.*, VIII, pp. 325-346, 1872).

In 1865-66, after finishing his coalfield work Ball began his examination of the metamorphic and crystalline rocks of the northern portion of the Manbhum district; he continued this work in 1866-67 accompanied by Ormsby, who was, however, soon incapacitated by sunstroke. His work, and that of Willson, Fedden and Ormsby, on this tract is described in the first portion of Ball's memoir on the geology of the districts of Manbhum and Singhbhum published some years later (*Mem. Geol. Surv. Ind.*, XVIII, Pt. 2. 1881).

The Vindhyans: Further west, two members of the Bengal Party(Mallet and Fedden) were at work in Central India and the Central Provinces. During the four seasons 1863-64 to 1866-67, Mallet continued the mapping of the Vindhyan formations in Rewah and Central India (1863-64), on the north side of the Nerbudda Valley from Hardua (N. W. of Jubbulpore) to Barwai in Indore (1864-65), along the northern edge from the

Sone Valley to Kalinjar Fort in the Banda district (1865-66), and along the western boundary between the crystallines and the Vindhyans from Bharatpur to Nimach in Central India followed by work in the Lalitpur and Jhansi districts (1866-67). In the course of his travels Mallet also studied the Bijwars and the crystalline rocks to the north of the Vindhyan boundary in Central India. Whilst Mallet was thus engaged, Hacket helped, first by work on the Deccan Trap and the intertrappeans to the north and west of Saugor, and later, for three seasons, in the country round Gwalior. The results of these joint labours are described in Mallet's memoir, 'On the Vindhyan Series, as exhibited in the North-Western and Central Provinces of India' (*Mem. Geol. Surv. Ind.*, VII, pp.1-129, 1869), which must certainly be regarded as one of the classics of Indian geology. It incorporates the work not only of Mallet and Hacket, but also of the two Medlicotts, W.T. Blanford (in the Dhar Forest), and of W.L. Willson (in Damoh and Saugor, in 1866-67). Taking H.B. Medlicott's three divisions of the Upper Vindhyans, Mallet sub-divides these into a number of what we should now call stages, introducing such terms as Sirbu, Ganurgarh, Jhiri, Panna and Bijigarh, for the various shales. He also recognises eleven stages in the Lower Vindhyans, and regards these investigations as proving the correctness of H.B. Medlicott's surmise in 1860, that the sub-Kymore series of the Sone valley and the Semri series of Bundelkhand are the same; and he distinguishes both the latter as Lower Vindhyans. Two of the illustrations in this memoir are from sketches by T. Oldham.

Whilst this Vindhyan work was in progress, H.B. Medlicott made another of his reconnaissances, this time (1865-66) of the western boundary of the Vindhyans and the Deccan Trap from Gwalior via Bundi in Rajputana to Nimach in Central India.

Chota Nagpur and Raipur: Whilst the party was systematically carrying on the detailed examination of the coalfields and adjoining districts it became necessary to make preparations for the extension of the labours of the Survey into the country lying further to the south: and in pursuance of this object H.B. Medlicott, in the season 1866-67, made another of his lengthy reconnaissances, visiting the country south of the Hazaribagh-Raniganj line to as far south as the Mahanadi River. The country thus traversed, included Chota Nagpur, Chhatisgarh, Raipur, Bilaspur, Sambalpur and Singhbhum. One result of this tour was the determination that the rocks of the Raipur basin did not belong to the coal-bearing series, as had been thought by the Rev. Mr. Hislop (the pioneer in the study of the geology of this part of the Central Provinces as far as Nagpur to the west), but formed instead a much older series, which Medlicott regarded as belonging to the Vindhyans. Whether these rocks of Raipur should be regarded as Lower Vindhyans or instead, as belonging to the still older Cuddapahs is still not certainly settled.

Assam Coal: Before we leave the work of the Bengal and Upper Provinces we must refer to still another piece of work by Medlicott. In 1864-65, he was sent on 'detached duty' to Assam at the urgent request of the

Government of Bengal to make a cursory and general examination of that province with a view to determine whether the coal known to exist there was of high enough quality and in sufficient quantity to justify exploitation for the benefit of river steamers on the Brahmaputra river, and for the tea plantations. As illustrating the vagaries of the Indian climate one may mention here that Medlicott's departure was delayed for a month as a result of the 'terrific cyclone' of the 5th of October, 1864, which caused the destruction of many river steamers including the one on which Medlicott's passage had been reserved. Medlicott was, however, able to visit all the important points in the valley of Assam and to establish the existence to the south of the Brahmaputra river of wide-spread and valuable seams of coal of good quality, the principal fields visited being those of Makum and Jaipur (see *Mem. Geol. Surv. Ind.*, IV, pp. 387-442, 1867). In his report he makes recommendations on the conditions that should attach to mining grants.

The North-West Himalaya : There still remain to be considered travels in the most distant part of 'Bengal and the Upper Provinces', namely the North-West Himalaya. In the summer of 1861, Mallet and Theobald visited Chini in the Sutlej Valley, and also the Spiti Valley, and made a collection of Mesozoic and Palaeozoic fossils. In 1863, Stoliczka made an expedition into the Himalaya not recorded by Oldham (see La Touche's Bibliography, Stoliczka, Paper I; and also *Mem. Geol. Surv. Ind.*, V, p. 141). In the monsoon period of 1864, Mallet and Stoliczka were sent by Oldham to the higher Himalaya

> 'to work out still further and more carefully than had previously been done, the structure of these very interesting regions. The occurrence of well preserved fossils in the districts of Spiti and Rupshu had been known for nearly half a century. Many of these had been brought down by successive travellers, and collections of them existed in several Museums both in this country and in Europe'. (Annual Rep. for **1864-65,** p. 6).

This visit was made necessary because these collections made by earlier travellers showed an intermixture of organic remains from very distinct groups of rocks. In this joint expedition, Mallet's previous acquintance with the ground was combined with Stoliczka's 'great experience and intimate knowledge of the European representatives of the rock groups which occur in Spiti and the adjoining districts' acquired during his connection with the Austrian Geological Survey. The fossils collected during this expedition ranged in age from Silurian to Cretaceous, and the results of these joint travels were published in two papers in the Memoirs. The smaller and less important of these was by Mallet (*Mem. Geol. Surv. Ind.*, V, pp. 153-172, 1865), and dealt with the gypsum of Lower Spiti and other minerals collected on this expedition[1] .

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[1] Amongst the minerals noticed is a green chrome garnet, found with chromite associated with the serpentinous rocks of Hanle, that may be new to science. Mallet gives an analysis based on only a small amount of material, but mentions particularly the absence of lime, an essential constituent of uvarovite, the only known chrome garnet. Unfortunately, further tests cannot be made as no trace of Mallet's specimen can be found in Calcutta.

The other Memoir (*Mem. Geol. Surv. Ind.*, V, pp. 1-154, 1865) is by Stoliczka and is entitled 'Geological Sections across the Himalayan Mountains, from Wangtu-bridge on the River Sutlej to Sungdo on the Indus ; etc.' It outlines the geological formations of this part of the Himalaya, and introduces local stratigraphical terms, such as *Babeh, Muth, Kuling, Lilang, Tagling, Spiti, Giumal and Chikkim*, some of which have been later replaced by European terms such as Triassic and Liassic, whilst others have stood the test of time and appear in the Index to the 1931 Geological Map of India. This memoir is accompanied by a plate of coloured sections across the Himalaya and several plates of the fossils collected, and represents a splendid piece of pioneering.

The ages of Stoliczka's formations were assessed by him as ranging from Silurian to Cretaceous, the former term being used in its older sense to include Ordovician. It has since been found that the oldest of these series, the Babeh beds, range down into the Cambrian[1]. In addition, he introduced the term *Central Gneiss* for what he regarded as the main geological axis of the North-West Himalaya of which the type locality may be regarded as the gneiss exposed from Wangtu-bridge on the Sutlej, up to the Babeh Pass. It is described as a porphyritic granitoid gneiss with veins of albite-granite.

In the following summer (1865), Stoliczka achieved a tremendous physical *tour de force*, leaving Simla on the 1st May and returning thereto on the 31st October. During this journey he visited Kulu, Lahaul, Rupshu, Leh, Zanskar and Kargil, and thence went via Dras to Srinagar in Kashmir; he returned to Simla via Kishtwar, Chamba and Kangra. It is not surprising that Oldham records that the fatigues and exposure during this trying and laborious march told rather severely on Stoliczka's health. Some of the results of this great journey are recorded in a short paper on the visit to the Provinces of Western Tibet, as Stoliczka calls a part of the country traversed (*Mem. Geol. Surv. Ind*, V, pp. 337-354, 1866). It is sometimes forgotton that a portion of the wide territories of Kashmir is known as Little Tibet, and that the inhabitants of these parts are by race allied to the Tibetans. The principal new discovery arising from this second expedition was that of the nummulitic beds of the Indus Valley in Ladakh, which Stoliczka refers to as the *Indus* or *Shingo* beds. Stoliczka regarded these two papers as preparatory to a more detailed account of the geology of the North-West Himalaya, to be written after further travels.

The Bombay Party

As a result of the increase in the number of Assistants in 1862, Oldham was at last able to arrange for the examination of the Bombay Presidencey. W. T. Blanford, transferred from Burma, was appointed Deputy Superintendent, with Wynne and Wil-

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[1] For the subsequent changes of nomenclature resulting from later researches by others, such as Griesbach and Hayden, see Hayden's 'Geology of Spiti', *Mem. Geol. Surv. Ind.*, XXXVI, (1904).

kinson to help him: and in 1863-64 they made a general survey of more than 9,000 square miles of country. Their first task was to connect the western end of J.G. Medlicott's ground in the Nerubdda Valley with the sea at the Gulf of Cambay. This was done by Blanford and Wynne during this field seasons: and Oldham expresses justifiable pride and pleasure in the completion of this line of geological survey across the Peninsula from sea to sea, stretching, as he remarks, over nearly 18 degrees[1] of longitude (An. Rep. 1863-64, pt.5). During this same season Wynne also made a detailed survey of the island of Bombay (*Mem. Geol. Surv. Ind.*, V, pp. 173-225, 1866).

Wilkinson and the Konkan : Wilkinson, in 1863-64, mapped in the Konkan, in Ratnagiri and Savantvadi, but, after resuming in the following season he had to abandon the field on account of ill health, and he finally resigned from the service in January 1865. Nevertheless, Wilkinson had succeeded in mapping the distribution of crystallines, Deccan Trap, and laterite, from the border of the Portugese territory of Goa, as far north as Ratnagiri: and the boundaries of these formations, including the inlier of Purana rocks to the north-east of Malvan, shown on the 1931 Geological Map of India, are based on his work[2].

Cutch : During the same season (1863-64), Blanford made a special visit to Sind to examine the lignitic coal of Lainyan near Kotri (*Mem. Geol. Surv.Ind.*, VI, pp. 1-15, 1867). When returning from Sind, Blandford made a rapid visit to Cutch, at Oldham's special request, to examine some fossiliferous rocks of Oolitic age that had been long known to exist (C.W., Grant, *Geol. Trans.*, Ser. 2, V, p.269, 1837). As a result of this visit Blanford was able to determine that certain beds containing plant remains (*Palaeozamia*, etc.) and imperfect layers of coal were intercalated with marine beds containing Jurassic fossils; thus providing evidence bearing on the age of beds with similar plant remains in other parts of India, *e.g.* Rajmahal and Madras (*Mem. Geol. Surv. Ind.*, VI, p.17, 1867).

Western India : In the next season (1864-65), Blanford and Wynne continued their surveys in the Nerbudda Valley, the geology of which proved both interesting and complex. The interest lay partly in the study of the marine Cretaceous beds (the Bagh beds). The results of this work are contained in Blanford's memoir 'On the Geology of the Taptee and Lower Nerbudda valleys and some adjoining districts' (*Mem. Geol. Surv. Ind.*, VI, pp. 163-394, 1869). Blanford points out the connexion between the Bagh beds, which are marine, and the Lameta beds of Jubbulpore,

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1 This seems to be a mistake for sixteen. For comparision it may be mentioned that the width of the British Isles from Kerry in the west to Norfolk in the East is about 12 degrees of longitude.

2 Wilkinson's only published paper is a 'Sketch of Geological structure of the Southern Konkan', *Rec. Geol. Surv. Ind.*, IV, pp. 44-47, 1872, in which he describes the results of this work.

which are freshwater. This memoir is also of special interest to students of pre-Cambrian rocks because in it, the author distinguished four Azoic groups, namely the Vindhyans, the Bijawars, the Champaners (Champaneers) and the metamorphic series.

Champaner beds : Blanford is quite definite that his Champaner group of rocks is distinct from the Bijawars. The two series of rocks do not, however, occur together; Blanford distinguishes them for lithological reasons and says, of the Champaner beds (*loc.cit.*, p. 202):-

> 'It is by no means clear whether, if distinct, they are higher or lower in the general series; they vary greatly in the extent to which they are metamorphosed, and they are, in the area examined, entirely isolated; very probably they do not differ greatly in age from the Bijawars'.

But in his list of formations (*loc. cit.*, p. 189) he places the Champaners below the Bijawars. This may be because the apparent passage of the Champaners into metamorphics is much stronger than that of the Bijawars. After attempting to discount this passage, in the case of the Champaners he writes (*loc. cit.*, p. 205) :-

> 'but still there is, in places, an apparent gradual change, both along the line of strike and across it, from Champaner beds into metamorphics'.

Later work, this century, has shown that the Chanpaners are of same formation as the Aravallis of Rajputana. By right of priority, therefore, the terms *Aravalli* and *Dharwar* now in use and proposed at much later dates (Aravalli, by Hacket, in 1877; and Dharwar, by Foote, in 1886) should be repalced by *Champaner*, as the general designation for these old schistose series. Geologists in India have, however, agreed not to follow slavishly the often inconvenient, indeed ridiculous, behaviour of many botanists and zoologists who allow the rigid application of rules of priority to upset well established names, and even produce such absurdities as *Auser auser* for the goose[1].

Nagpur : Wynne fell ill towards the end of the field season of 1865-66 and returned to England on medical certificate. In 1866-67 he was still absent on leave, and Fedden was sent to fill the void. Although it lay outside the limits on the Bombay Presidency, Thomas Oldham allowed Blandford to devote a part of the field season to the survey of the country round Nagpur (see *Mem. Geol. Surv. Ind.*, IX, Art. 2, 1872) and thence southwards as far as Chanda and the Godavari valley. This was suitable because Blanford had already visited Betul and the recently discovered

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[1] This Memoir by Blanford noticed above is of special interest to the present writer as he spent his first field season in India under the tutelage of Mr. E. V. Vredenburg surveying in the Dhar Forest and adjoining districts to the east. It was in the course of this survey that Vredenburg proved the equivalence of the Bagh beds and the Lametas, suspected by Blanford. See T. H. Holland, *Gen. Rep.* for 1902-03, p. 20.

coal of Chhindwara. Blanford thereby became the first geologist to visit some of the Wardha Valley coalfields, e.g. the Ghugus-Telwasa (Khumbari) and the Sasti coalfields (see An. Rep., 1867, pp. 10-11).

The Deccan Trap : Before leaving the work of the Bombay party we must mention the small memoir in which Blanford summarised the results of the work by Wynne and himself during some five years on the Deccan Traps; a memoir entitled 'On the traps and intertrappean beds of Western and Central India' (*Mem. Geol. Surv. Ind.*, VI, pp. 137-162, 1867). Though short, this paper contains a succinct account of the structure, distribution, and origin of the traps of Western India that has stood the test of time, and it must be regarded as one of our geological classics. The author points out that rocks previously regarded as intrusive volcanic breccias are ash beds. He notices the horizontality ot the traps, their wide extent, the absence of volcanic foci, and that the traps are of terrestrial and not of sub-marine origin. They cover roughly 200,000 square miles of country, and are at least 5,000 feet thick; and in view of the presence of intertrappean beds with freshwater fossils an enormous period of time must have been necessary for the total thickness of lavas to accumulate. On the age of the traps Blanford is not dogmatic. He shows that they overlie the Bagh beds, regarded by him as of Upper Greensand age, and are in 'places, *e.g.*, in Surat, overlain with a marked unconformity by beds of nummulitic age, the basal congolmerates of which contain pebbles derived from the erosion of the traps. He regards the evidence of age as far from conclusive but observes (*loc.cit.*,p. 160) that 'it appears highly probable that part, at least, of the traps are upper cretaceous in age'. He suggests that the uppermost flows of Bombay and Mahabaleshwar might have been contemporaneous with the oldest Tertiaries. The tendency of recent years has been to ascribe the whole of the vast thickness of the Deccan traps to the Tertiary period. This tendency has, however, probably been allowed to go too far, and I personally have always found it wise to 'gang warily' when tempted to disagree with Blanford's conclusions. It is, I think, wise to realise that the evidence for a Tertiary age for the whole mass of the Deccan trap flows is not conclusive, and that it is still not impossible for evidence to be produced that this period of vulcanicity began in Upper Cretaceous times, even though the bulk of the flows was erupted in the Eocene.

Zeolites : Whilst the Bombay party was at work, the Great Indian Peninsula Railway line on the Bhor and Thal Ghats towards Poona was under construction. The railway cuttings provided some magnificent sections of the traps, exposing highly vesicular flows with large geodic cavities. From these railway cuttings, large collections were made by Blanford in 1862-63 and 1863-64 of the splendid crystals of various zeolites, particularly of apophyllite, stilbite, and heulandite ; and it is from these collections that the magnificent and beautiful specimens now in the Indian Museum, Calcutta, and in the Natural History Museum at South Kensington, were selected.

Collections were also sent to the Imperial Mineral Cabinet, Vienna, and to the Royal School of Mines, London in return for specimens received from these institutions (An. Rep., 1864-65, p.13). One of the most striking of these associations of zeolitic minerals is of large colourless crystals of apophyllite on a mass of orange stilbite.

Abyssinia : At the end of 1867, Blanford was deputed to accompany the British military expedition to Abyssinia as geologist. The scientific results of this expedition are given in his book entitled 'Observations on the Geology and Zoology of Abyssinia' (Macmillan & Co., 1870). Blanford was intrigued by the apparent resemblance between the basaltic lava flows of Abyssinia and those of the Deccan.

Trans Frontier Expeditions : This visit of Blanford to Abyssinia inaugurated a policy that has been adhered to ever since of deputing geologists from the Geological Survey of India to accompany military boundary, railway, and other expeditions beyond the frontiers of India, as a result of which valuable contributions have been made to the geology of adjoining countries, such as Persia, Afghanistan, Tibet and Western China. In addition, much of the geology of the unadministered tribal tracts on both the north-western and the north-eastern frontiers has only been opened to investigation during military expeditions.

The Madras Party

During the years 1861 to 1867, the Madras Party consisted as before of C.A. Oldham in charge, with W. King and Bruce Foote; none of the five extra Assistants appointed in 1862 were attached to this party. Oldham became Deputy Superintendent in 1862, when this title was introduced. These three men continued to work steadily northwards up the eastern coastal tracts of the Carnatic, and the flanking Coromandel section of the Eastern Ghats, through the districts of Salem, South and North Arcot, Madras, Nellore, Cuddapah, Karnul, and Kistna. This is a country with a basis of Archaean crystalline rocks, largely gneisses, with the overlying great Cuddapah basin of pre-Cambrian stratified sandstones, limestones and shales, and with a coastal fringe of alluvial deposits, laterite, Cuddalore sandstones, younger plant-bearing beds, and the marine Cretaceous beds already noticed in the discussion of the period 1856-61.

The progress of the party was interrupted periodically by the leave of one or other of its members, and still more by illness, especially by cholera. Foote himself was once a victim of this, but fortunately recovered (1863-64); and C. Oldham's camp was afflicted by a wave of cholera (1864-65) when he lost several of his servants; whilst in the following season (1865-66) Oldham's work had to be suspended because of an outbreak of this disease in the country which he was surveying.

Nevertheless, by the end of 1867 the party had completed, since they began work in 1857, the survey of an area equal to four of the full-

sized Atlas of India sheets and as T. Oldham notes (An. Rep., 1862-63, p. 5), each sheet covers some 14,500 square miles representing an area twice as large as the whole Principality of Wales.

Trichnopoly, Salem and South Arcot : One systematic memoir was published during this period, namely a joint memoir by King and Foote 'On the Geological Structure of portions of the districts of Trichinopoly, Salem and South Arcot, Madras' (*Mem. Geol. Surv. Ind.*, IV, pp. 223-384, 1864). This area is included in Sheet 79 of the India Atlas, but the Memoir is not illustrated by a corresponding geological map. However, according to T. Oldham (An. Rep., 1866-67, p. 10), Sheet 79 of the Indian Atlas was subsequently published separately in four quarter sheets geologically coloured, which were issued in 1866-67. I have, however, never seen these maps, and they appear never to have been listed amongst the publications of the Geological Survey either earlier or in the latest compilation (*Mem. Geol. Surv. Ind.*, LXXVII, 1948), and what happened to them remains a mystery.

This memoir by King and Foote naturally omits from discussion the Cretaceous rocks already described by H. F. Blanford in the first part of the same volume of *Memoirs*. The formations described are the recent deposits-laterite, Cuddalore sandstone and the metamorphic rocks. The laterite, which of course is of the low-level variety, is shown to be unconformable to the underlying Cuddalore sandstones. The metamorphic rocks were mapped and described before the application of the microscope to the study of rocks, so that the gneisses of the Shevaroy Hills and other mountain masses that we now know as built of hypersthenic rocks (of the charnockite series) are referred to as hornblendic gneisses, as in H. F. Blanford's memoir on the Nilgiri Hills. Bands of crystalline limestone are mapped in the Trichinopoly district and their disposition is found to be that of a broad anticline with a W.N.W. axis. The magnesite veins of the Chalk Hills, Salem are described, and also the occurrence there of chromite. An important vein of this latter mineral was formerly worked by Mr. Heath of the Porto Novo Iron Company and the chromite shipped to England[1]. The valuable magnetic iron ores of Kanjamalai, near Salem, are described in an appendix, probably by Foote, and an account is also given of indigenous methods of smelting and refining in the Salem district with the production of 'wootz' or Indian steel.

Jurassic plant beds : In 1863-64, an important discovery was made by Foote of fossiliferous beds (near Sripermatur, S. W. of Madras) in which marine fossils of Jurassic age were found in beds intercalated with others holding an abundance of vegetable remains. The plant fossils were apparently of the same species as those found in the Rajmahal Hills and Cutch. W. T. Blanford, having recently seen the latter, was sent by

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1 Described by T. J. Newbold, *J.A.S.B.*, VII, pp. 167-171, 1842.

T. Oldham on a visit of inspection and arrived at the conclusion that these Madras beds must be regarded as of undoubted Jurassic age. (An. Rep., 1863-64, pp. 8 & 9). Patches of similar plant-bearing beds were found by C. Oldham and King as far north as the vicinity of Nellore.

Palaeolithic stone implements : During the same field season, 1863-64, King and Foote, almost simultaneously, discovered chipped stone implements over a wide extent of country to the west and north of Madras city, and in great quantity, the material used being the semi-vitreous quartzites of the Cuddapah rocks[1]. The implements were found both on the surface and also enclosed in the superficial deposits of the flat country to the West of Madras. During 1864-65, V. Ball found a similar implement made of a precisely similar material lying on the surface in the Jharia coalfield, and Theobald found implements of a later type in British Burma. Further, in 1865-66, Wynne found an agate knife-like flake near the village of Pyton in the gravels of the Upper Godavari, whilst H. B. Medlicott found on the surface near Nimach in Central India chipped stone weapons similar to those found so plentifully in Madras Presidency. These interesting and often important discoveries were reported in a number of small papers and Foote, when on leave, read a paper to the Geological Society of London 'On the Distribution of Stone Implements in Southern India' (*Q.J.G.S.*, XXIV, pp. 484-495, 1868). The importance of Foote's discoveries lies in the fact that many of the implements were actually embedded in the laterite-conglomerate of Madras[2]. Foote retained throughout the remainder of his service and life the interest thus aroused in stone implements, and the large and valuable collection made by him is now in the Madras Museum, and is known as the Bruce Foote collection.

Amongst other officers who have followed in Foote's footsteps and become greatly interested in Indian stone implements are V. Ball and, in the present century, J. Coggin Brown. One of the most interesting points connected with these Indian stone implements is the 'precise similarity in form and design which exists between those found in India and those in Europe'; and as Theobald notes (*Mem. Geol. Surv. Ind.*, X,pp. 355-359), when discussing the stone implements of Burma

> 'but so far as known specimens of Indian implements allow us to judge and apart from the indication afforded by the material (flint so commonly used in Europe not occurring in India), it would be difficult to say from shape of manufacture whether any particular implement *of* palaeolithic type had been manufactured in Kent or Cuddapah, or if a particular

[1] An. Rep., 1863-64, p. 10. Is this an advance use of the term 'Cuddapah' as the name of a geological formation? If so it precedes by several years King's introduction of the term with the spelling 'Kadapah' in *Mem. Geol. Surv. Ind.*, VIII, 1872.

[2] See *Mem. Geol. Surv. Ind.*, X. pp. 43-58 (1873), for the details of some of the sections in which these implements were found.

neolithic celt of greenstone was from the neighbourhood of the Son or the banks of the Shannon'.

North-south and east-west geological sections of India

With reference to future work in the Madras Presidency Thomas Oldham reports that a general reconnaissance of the rocks to the north had been arranged and that Mr. C. Oldham had started on this work; and that with the investigations of the Survey rapidly advancing in both directions—from the north southwards, from Nagpur and the Godavari, and from the south northwards, from Madras, Cuddapah, and Kurnool—so as to effect a junction, it will require only a few more years to complete a geological section from the plains of Tibet to the Gulf of Manaar (An. Rep., 1866-67, p. 6). In this reference to Tibet, Oldham was not thinking of the nearer parts of Tibet to the north of Darjeeling and Bengal, but to the more distant parts to the north-east of Kashmir (Little Tibet) visited by Stoliczka. This north and south section when completed would cross at Nagpur the east and west line of section already completed.

Burma

Work in Burma continued throughout this period, 1861-1867. The geological survey of the province of Pegu was commenced by W. T. Blandford in 1860, assisted by Fedden, and these two in two seasons completed the examination of the districts of Henzada and Bassein, and of a portion of the Rangoon district also. Blanford was then transferred (1862) to Bombay as Deputy Superintendent of the newly formed Bombay Party, as already related; and, after another season mapping in western Prome, Fedden was deputed (1864-65) to accompany a surveying expedition to examine the course of the Upper Salween. On his return therefrom he was also withdrawn from Bombay, and Theobald, who had been in Burma from the field season of 1862-63 worked on alone to the end of this period (1861-67). This reduction of staff employed in Burma was due to the delay in the issue of maps of the Survey of British Burma prepared by Captain Fitzroy, and the disadvantages of working with the very imperfect sketches available. During these years the Burma party, mainly Theobald, had worked steadily northwards from the Irrawaddy delta into the Arakan Hills and the Pegu Yoma and up the Irrawaddy valley to the north of Prome. Theobald's work will be noticed in the account of the next period (1868-76), but one point that he had established during this period was the absence of evidence of the existence of nummulitic rocks to the east of the Irrawaddy river.

Blanford, before his transfer to India, had succeeded in obtaining vertebrate fossils in the Irrawaddy valley, and had also visited the extinct volcano Puppadoung or Mount Popa[1]. In the summer of 1867, Theobald left India on furlough 'after a continuous and useful service of eighteen

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[1] *J.A.S.B.*, XXXI, pp. 215-226, 1862.

years without absence'. This was a remarkable feat of endurance. The eighteen years includes of course, his previous service with McClelland and Fleming.

The Geological Museum

During this period 1861-1867, great progress was made in securing collections for the newly established Geological Museum. In addition to rocks, minerals and fossils obtained by officers in the field in the course of their investigations numerous collections of fossils were received from various sources in Europe—England, Vienna, Paris, Switzerland—partly in return for Indian collections, specially of the Cretaceous fossils of Southern India; Theobald and Stoliczka also each presented foreign collections. Finally in 1867, Oldham, when visiting European collections, succeeded in persuading the Secretary of State for India of the desirability of purchasing a valuable collection then available, the result of 25 years researches by Prof. Von Klipstein. Thus was obtained the fine reference set of invertebrate fossils in the Indian Museum still known as the Klipstein Collection. This collection when shipped was contained in over 200 cases, and it is not surprising therefore that Oldham was already finding the premises at No. 1 Hastings Street too cramped! (*An. Rep.* 1867, p. 12).

The collection of meteorites

Another collection worthy of special notice is that of meteoric stones and irons formerly belonging to Professor Robert Philip Greg of Manchester, containing specimens of 223 falls and acquired by purchase (1865-66). This, added to the specimens already in the Geological Museum, and to others subsequently obtained, brought the Survey collection to 247 falls (152 stones and 95 irons) by 1867, and justified the statement made by Oldham in a Catalogue of Meteorites in the Geological Survey Museum (his third such catalogue: 1867), that this collection stood amongst the first in the world. In India, owing to the large size of the country and the outdoor life of so large a proportion of its inhabitants, an average of about one aerolite a year is seen to fall and recovered. Such falls are by law the property of the Government of India and thus usually find their way to the national collection, which is that of the Geological Survey of India[1]. It is not surprising, therefore, that with the aid of these frequent accessions, and the use of a part of them for exchange purpose, this collection has continued to rank as one of the world's great meteorites collections.

Publications

During this period 1861-1867, the publication of the *Memoirs* of the Geological Survey of India continued as material became available and the papers in the first six volumes, including the account in Volume VI by Wynne and Stoliczka of the fossil frog beds in the Intertrappeans of the Island of Bombay, all represent work done up to the end of 1867, as does also Mallet's Vindhyan Memoir, and Hughes's[1] Karanpura memoir, in Volume VII of the Memoirs and Blanford's memoir on the Geology of Nagpur in Volume IX.

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1 *See Mem. Geol. Surv. Ind.*, Vol. 75, p. 11., 1940.

In the *Palaeontologia Indica*, the publication of accounts of the Cephalopoda (1861-65) and Gastropoda (1867-68) in the Cretaceous Fauna of Southern India by Stoliczka continued. The fossil flora of the Rajmahal series in the Rajmahal Hills was described by T. Oldham and J. Morris (1863) and the vertebrate fossils from the Panchet beds by Thomas H. Huxley (1865). An attempt was made to issue the fascicles of the Cretaceous Fauna of Southern India in regular quarterly instalments, and Oldham takes periodic pride in the achievement when, at intervals, publication gets ahead of schedule.

In addition, the publication of Catalogues of collections in the Museum was commenced, of which the meteorite catalogue mentioned above was an example.

Recess Work

During the recess season for work in the plains of India, the geologists, as a rule, returned to Headquarters in Calcutta to prepare their maps and reports and examine their field collections. Leave due, or necessitated by illness, was usually taken during this period so as not to interfere with the field season. This was also the season for field work in the hills, when such work was required. In addition, Oldham encouraged such as could carry out in the hills their recess duties without interruption to take advantage of the benefits derivable from a colder climate. The Madras Party does not appear to have recessed in Calcutta. Foote and King are both recorded as having arranged the collections in the Central Museum, Madras.

Geological Lectures

Foote also gave lectures on geology at the College of Civil Engineering, Madras to which the public were admitted. (An. Rep., 1861-62, p. 4; 1862-63, p. 5). In the first season, 20 out of 47 Engineering students passed the examination held after the lectures. In the recess of 1866-67, C. Oldham gave these lectures, and King was engaged in the preparation of a catalogue of the minerals in the Central Museum. The whole series of fossils in this Museum were sent to Calcutta and after cataloguing returned to Madras. In his Annual Report for 1861-62, Thomas Oldham looks forward to the establishment of lectures in Calcutta 'where at present there are no means available for acquiring a knowledge of geology and its applications'. In 1863-64, Oldham records that a small series of fossils and minerals had been placed at the disposal of the Presidency College, Calcutta, to illustrate lectures on Geology and Mineralogy.

In closing the account of this period of 1861-1867, we arrive at the end of the time when the Annual Reports of the Superintendent were necessarily published separately. These reports are not included in any other publication, have long been out of print, and are very scarce and difficult to obtain, even for consultation. It is for this reason that the account of the progress of the Geological Survey of India so far given is more detailed than might otherwise have been thought either desirable or suitable.

With the opening of the final period of Oldham's service, 1868-1876, the new publication of the Department, the *Records of the Geological Survey of India,* was commenced, and from thence the Annual Report of the Superintendent appears in these *Records,* usually in the first of the four parts that constitute each annual volume.

CHAPTER VII

THE GEOLOGICAL SURVEY OF INDIA UNDER DR. THOMAS OLDHAM (*Concluded*)

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Staff: Thomas Oldham started this fourth period with the following staff:—

Deputy Superintendents:	H. B. Medlicott, W. T. Blanford and C. A. Oldham
Assistants:	Theobald, W. L. Willson, King, Foote, Mallet, Fedden, Hacket, Hughes, Wynne, Ball and Ormsby.
Curator:	Tween
Palaeontologist:	Stoliczka

The losses during this period were three in number, namely Charles Oldham (1869), Ormsby (1870) and Stoliczka (1874).

Charles Aemilius Oldham, who had left India on furlough in November, 1868, died in April, 1869. Of him, Thomas Oldham writes (*Rec. Geol. Surv. Ind.*, III, p. 1):

> 'In him the Government of India lost a trained and able servant, distinguished for his conscientious devotion to duty, and for the care and skill with which he, as Deputy Superintendent for Madras, conducted the labours of the party working there. This death, resulting from the effects of an attack contracted during his active service in India, adds another to the long list of those who have succumbed to the very trying exposure in the worst and most unhealthy parts of the country which the pursuit of Geology in India necessarily entails'.

Charles Oldham had completed 13 years service at the time of his death. Practically, the whole of his service was spent in the Madras Presidency, where he succeeded H. F. Blanford in the charge of this work in 1862. His field work was done in conjunction with King and Foote in the Coromandel coast and in the Cuddapah basin, and is referred to in numerous annual reports, and in the memoirs of King and Foote; but

he himself did not publish any geological papers[1]. A chapter of Boswell's 'Manual of the Nellore District in the Presidency of Madras' (1873), contains a chapter on Geology and Soils compiled from notes supplied by Oldham and C. Rundall. Charles Oldham was a nephew of Thomas.

M. H. Ormsby died in June, 1870 apparently from the after effects of exposure to the sun in 1868, which recurred in 1870 after his return from leave. He worked with Ball on the geology of Manbhum (*Mem. Geol. Surv. Ind.*, XVIII, p. 7), and had also completed the revision of a large section of the Bhagalpur district, the completion of which was interrupted by his illness (*Rec. Geol. Surv. Ind.*, IV, p. 3, 1871). The only paper to his name is one entitled 'Analysis of some Granitic Rocks from India, and of their Constitutent Minerals (1868)' published posthumously (*Jour. R. Geol. Soc.*, Ireland, III, pp. 26, 27, 1871).

The death of Dr. Ferdinand Stoliczka on the 19th June, 1874 was the greatest loss of all. This happened at Leh, on his return from the Yarkand mission to Kashgar to which he had been attached as naturalist and during which he also succeeded in visiting the Pamir Steppe. He was returning to India laden with a rich and valuable zoological collection. As Thomas Oldham writes, he had fallen 'a sacrifice to his over-exertion in the cause of science', at the early age of 36. It is fitting to quote here Oldham's tribute to this great palaeontologist (*Rec. Geol. Surv. Ind.*, VIII, p. 2, 1875):

> 'Gifted by nature with peculiar powers of observation and comparision trained in an accurate and careful school of Geology and Palaeontology, he brought to his labours unbounded zeal, acute intelligence, and large and carefully acquired knowledge, all of which tended to render him one of the most useful and most trusted of our colleagues. But in addition to this, his genial temperament, his sound judgment, and his hearty appreciation of work of any kind in others, together with his clear views of justice, and the unflinching expression of those views, made him also one of our most esteemed and beloved friends and advisers ... He has left behind him a noble monument of his research and powers in the Palaeontologia Indica .... in which, just before his departure for Yarkand, he had completed the description of the Cretaceous Fauna of Southern India in four large volumes with 203 plates. And fortunately for the Survey, he has also left behind him a very fitting and competent successor in Dr. Waagen,long his trusted fellow labourer and assistant'.

The reliance placed by the Department on Stoliczka's palaeontological knowledge is illustrated by a passage of Medlciott's in which he refers to Stoliczka in the year before his death, as 'our palaeontological oracle' (*Rec. Geol. Surv. Ind.*, VII, p. 2)

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[1] He would, however, probably have written the Memoir on the Nellore portion of the Carnatic. See King's. *Mem. Geol. Surv. Ind.*, XVI, p. 2 (1880).

During this final period of Thomas Oldham's service, the following additions were made to the staff of the Geological Survey of India, not in order to increase strength, but to replace losses due to death and resignation:—

1. 5.1868	Mark Fryer: As Mining Specialist
15.12.1870	Dr. Wilhelm Waagen
3. 1.1871	Jos. W. Alexander
1. 9.1871	James Willson
26.11.1874	Richard Lydekker
28. 3.1875	Dr. Ottokar Feistmantel

Of these, only Lydekker and Feistmantel were still in the Department at the time of Thomas Oldham's retirement in 1876.

Mark Fryer, after starting the prospecting operations in Chanda to be noticed later, was apparently seconded to the Central Provinces administration in March, 1870 (*Rec. Geol. Surv. Ind.*, IV, p. 1; and V, p. 2). He does not appear to have returned to the Geological Survey. He then went to Burma and appears as the author of several papers on mineral in the Tennaserim Division of Burma, published between 1872 and 1882. If his death is correctly recorded as having occurred on the 19th November, 1875 three of these papers must be posthumous.

Dr. Wilhelm Waagen, mentioned above in Oldham's tribute to Stoliczka, was appointed Palaeontologist on the 21st April, 1875, but was compelled by ill-health to resign from the service on 24th August of the same year. He later became Professor of Palaeontology at the University of Vienna, and died on the 24th March, 1899, at the age of 59. His principal contributions to Indian Palaeontology were a memoir on the Jurassic Cephalopoda of Kutch in the *Palaeontologia Indica* (Series IX, Vol. I, 1873-1875) issued during his service in India, and, after his retirement from India, a succession of contributions to Series XIII of the same publication on the 'Salt Range Fossils Productus-Limestone Group', published in seven parts between 1879 and 1887, with 988 pages of text and 128 plates. He was also the joint author with Wynne of a paper on the Geology of Mount Sirban in the Upper Punjab (*Mem. Geol. Surv. Ind.*, IX, pp. 331-350, 1872).

The next two Assistants in the list above soon left the Department and were lost to geology. J. W. Alexander was nominated (1.8.1871) by the Lieut. Governor of Bengal to the charge of the Maharaja of Darbhanga and his brothers and James Willson, who had for some time been already engaged in India as Professor of Mathematics, was speedily appointed to the Geological Survey in his place. Willson had obtained high honours in physics, geology and mineralogy at Trinity College, Dublin, so that he was well qualified for the Geological Survey (*Rec. Geol. Surv. Ind.*, V, p. 1, 10: VI, p. 2: VII, p. 4). Willson was sent into the field with Ball in Chota Nagpur in the 1871-72 field-season and spent the next field-season

on the Karanpura coalfields; and then in March, 1873, finding that the duties were more than his health could stand, he transferred his services to the Bengal Educational Service, to which the Geological Survey had already lost J. D. Medlicott & H. F. Blanford.

There are five other appointments to be noticed, though of a subordinate nature.

Jules Schaumburg was appointed on the 12th April, 1869, as Chief Draughtsman to the Department, and died on the 12th February, 1886. He has left behind him an enduring monument in the beautiful lithographed plates with which so many of our publications are adorned: e.g. of scenery (see Wynne's Salt Range Memoir, *Mem. Geol. Surv. Ind.*, XIV, 1878), of mining operations (see Ball's Economic Geology, 1881) and of fossils (see Medlicott and Blanford's 'Manual of the Geology of India', Vol. II, 1879).

An office appointment was that of Mr. W. R. Bion on 12th December, 1870 as Librarian. He became Chief Clerk in 1875, and Registrar on 31st December, 1878, and died on 22nd July, 1891. He was the father of the late Mr. H. S. Bion, who was appointed to the Geological Survey of India as Assistant Superintendent in 1911.

Thomas Oldham had often lamented the impossibility of recruiting geologists in India owing to the absence of provision for the teaching of this science (see *Rec. Geol. Surv. Ind.*, IV, p. 1, 1871). He had from time to time made attempts to establish teaching in certain branches of science in connection with the Geological Survey so that some general knowledge of these subjects might be diffused: this would, however, have involved some expenses for the remuneration of the teachers. In Madras, as already recorded, Foote and C. A. Oldham had each, during the recess reason, given lectures on geology to the engineering students of the Civil Engineering College. In addition, collections of fossils and minerals had been placed at the disposal of Presidency College, Calcutta, to illustrate lectures on geology and mineralogy.

When James Willson left the Department in 1873, Government decided not to fill his post, and instead to devote the pay of that appointment to an attempt to train Indian geologists through a system of apprenticeship. There were to be four such apprentices, and the first, Ram Singh, joined in February, 1873 (or ? March). Two others, Kishen Singh and Hira Lall, joined on the 7th January, 1874. There is no record that the fourth was appointed. These apprentices were all students of the Lahore College, and their qualifications were a moderate knowledge of English and of Elementary Mathematics. It was arranged that they should attend one or more courses of physical science lectures at the Presidency College, Calcutta (*Rec. Geol. Surv. Ind.*, VII, p. 8, 1874). Of these appren-

tices, Ram Singh was not a success and his services were dispensed with in 1877. But Kishen Singh and Hira Lall served their five years of apprenticeship with sufficient credit, acquired a serviceable knowledge of rocks and minerals, and, on the recommendation of the then Superintendent of the Geological Survey, Mr. H. B. Medlicott, they were given permanent promotion as Sub-Assistants on the 1st April, 1879 (*Rec. Geol. Surv. Ind.*, XIII, p. 10, 1880). They remained in the service until they retired on pension on the 6th March, 1903 and the 16th May, 1904 respectively.

Progress of work We must now discuss the work of the Geological Survey of India during Oldham's last nine years. The basis of this discussion as before, will be the Annual Reports of the Superintendent, printed in the newly established *Records of the Geological Survey of India*, in which they usually appear as the opening article. The reports for the years 1867 (already noticed) to 1875, printed in volume I (1868) to IX (1876) of the *Records*, were all issued whilst Oldham was still in the service, and were all from his pen except that for 1873 (*Records* VII), which is by H. B. Medlicott, who officiated as Superintendent during Oldham's absence from India on sick-leave in Europe in that year. The Annual Report for 1876 (*Records*, X, 1877) was the first written by Medlicott in his substantive position of Superintendent after Oldham's retirement in April, 1876 and covers the final portion of Oldham's service.

As Medlicott records (*Rec. Geol. Surv. Ind.*, VII, p. 1), 1873 was the first time after twenty-two years of continuous service that Dr. Oldham was compelled to take sick leave. On other occasions, when Oldham had been abroad, his absence appears to have been on duty connected with the affairs of the Department, such as recruiting and acquiring collections for the Museum. Thomas Oldham must have been a man of very tough physique to have been able to remain so continuously in harness without the periodic furlough, customarily taken by those serving in India. His illness of 1873 was a prelude to retirement in 1876, on grounds apparently of ill health and not of age (60).

When describing the progress of the Geological Survey during the previous periods of Oldham's service it has been convenient to follow the grouping of the geologists into parties corresponding to the three Presidencies of Bengal (including the Upper Provinces), Bombay and Madras, each in the charge of a Deputy Superintendent, with Burma as an appendage. The division of the work amongst these three parties was rendered geographically simple by the presence of the wide spread of the Deccan Trap lavas of Western India, which by their mere presence separated the Bombay Party for some years from the Bengal Party on the east, and the Madras Party on the south. The line of weakness was the valley of the Narbada river up, which W. T. Blanford penetrated in 1863-64 to shake hands, metaphorically, with the Bengal Party. Also, once Blanford and Wynne had crossed the Deccan Trap of Northern Bombay and Berar to Nagpur in

the Central Provinces via the Tapti river and its tributary, the Purna, contact with the Madras Party via the Godavari valley became feasible. We have seen how Oldham looked forward to this meeting. But it is not recorded that Blanford and King did actually shake hands in this Valley, although King surveyed in more detail ground in the Lower Godavari Valley where Blanford had been the pioneer.

It seems suitable to mention now that each of the Annual Reports of the Geological Survey of India, from the time of their very first institution, is accompanied by an Index Map of the Sheets of the Atlas of India 'Shewing present state of progress of the Geological Survey', different colours being used to indicate degree of progress made[1]. It is fascinating to glance at these maps one by one and thus follow the annual expansion of the area surveyed. In the map accompanying the 1868 report, the Bombay and Bengal work are joined for the first time, and, in addition, a process, like a pseudopodium, is seen extending down to Godavari Valley, but with still 140 miles to go to make contact with the Madras Party. In the 1870 report, the gap is reduced to about 50 miles; and in the report for 1871, the gap has disappeared, and the Madras Party had made contact with the work of the Bombay party, not only down the Godavari Valley (due to Blanford having penetrated as far as Ellore in the Madras Presidency), but also along the southern edge of the Deccan Trap to the west in the Belgaum district, where Foote's work joined that of Wilkinson. In 1871, therefore, Oldham's objective of connecting Southern India with Tibet (Little Tibet) was reached (if one overlooks the alluvial gap of some 50 miles to the north of Delhi).

When, in 1874, Medlicott wrote the Annual Report as Officiating Superintendent he remarks that it had never been convenient to adhere closely to this territorial division of the work of the department into three parties. He pointed out (p. 2) that:

> "Those who have studied certain formations must follow them out irrespectively of fiscal boundaries, and in so large a country, where communication is often difficult, it is commonly most convenient that each geologist should communicate independently with headquarters in Calcutta'.

What Medlicott wrote is, of course, correct; nevertheless, we will attempt in this fourth period of Oldham to follow roughly the order adopted in the preceding parts.

It must also be observed that the institution of the new series of Publication, the *Records*, issued quarterly, provided an outlet for brief

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[1] These maps were continued by Medlicott throughout his period of charge of the Geological Survey of India, up to Volume XX of the *Records*. His successor, W. King, continued this practice into Volume XXI, and then stopped it: and such maps have not since been included in the Annual Reports.

papers on work in progress, often published in advance of their notice in the Annual Report, and sometimes years before the results could be incorporated in well-rounded memoir on a district or subject.

Bengal and the Upper Provinces

During this nine years, surveying continued in several parts of Bengal and the Upper Provinces. The officers engaged in this party were Medlicott (in charge), W. L. Willson, Mallet, Hacket, Hughes, Fedden and Ball (with Ormsby for the short period before his death), and Wynne and Waagen in the Punjab.

Assam: Medlicott, as the Deputy Superintendent in charge, travelled widely. In 1868, he visited the western and southern flanks of the Garo Hills, Assam, to investigate reported occurrences of coal. In 1874, he was again to re-visit these hills and to penetrate more deeply. During these two visits, he was able to study the Cretaceous coal of the Someswari gorge and elsewhere along the southern face of the Hills, and the Daranggiri and other fields within the hills[1].

In 1868, after his first visit to the Garo hills, Medlicott also made a careful examination of a portion of the Khasia Hills, the results of which are described in his 'Geological Sketch of the Shillong Plateau' (*Mem. Geol. Surv. Ind.*, VII, pp. 151-207, 1871). In this, the sequence of the geological formations of the Assam Hills is determined and the nomenclature thereof proposed. The fossiliferous formations observed are marine Tertiary and Cretaceous beds, regarded as in conformable relationship but resting unconformably on unfossiliferous formations, comprising the Sylhet trap (thought to be of the same age as the Rajmahal trap), the Shillong series and the Khasi greenstone. The quartzities and schists of the Shillong series may be, Medlicott suggests, the equivalent of the quartzites and schists of Bihar, now regarded as Dharwarian. The greenstone is intrusive into the Shillong series, but prior to the principal contortion of the latter, this, again, leading to an analogy with the state of affairs in Bihar[2]. The granite of the Plateau is also intrusive and is younger than the trap. The relationship of the gneiss of the Shillong plateau was not determined. The fossiliferous Cretaceous beds are of great interest on account of their affinity to the Cretaceous beds of Trichinopoly.

In the winter of 1874-75, Mallet, at the request of the Assam Government, accompanied a civil expedition with police protection into the Naga Hills, so that he was enabled to examine at leisure the coalfields of that country. This work was really in extension of that by H. B. Medlicott in 1865, when the condition did not permit Medlicott to make a complete examination. The results of Mallet's work are given in his memoir 'on

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1 *Rec. Geol. Surv. Ind.*, I, p. 2 (1868) and VII, p. 58 (1874).

2 Medlicott applies to this relationship the term hypo-cotemporaneous or hypo-synchronous, the invention of which he ascribes to Ormsby (*loc. cit.*, p. 208).

the Coalfields of the Naga Hills' (*Mem. Geol. Surv. Ind.*, pp. 269-363, 1876), and are geologically important, as in this report Mallet established the main sub-divisions of the Tertiary sequence of Upper Assam in which the coal and petroleum of Assam are found. The stratigraphical sequence of Mallet, recognising as the main divisions the Dihings, the Tipam series, the coal measures, and the underlying Disang series and ranging in age from Pliocene to Eocene, has provided the basis of all subsequently geological work on the coal and petroleum occurrences of Assam. His maps show both coal seams and petroleum springs.

The Darjeeling Himalaya and the Western Duars : From Assam it is convenient (on paper, not in practice) to pass to the Darjeeling (and Sikkim) Himalaya and the Baxa Duars in North Bengal. A report of the existence of coal had caused Dr. T. Oldham to visit the Sivok valley as early as 1853[1], only to find that the coal was in Tertiary rocks and of no value. Dr. Joseph Dalton Hooker (afterwards Sir Joseph Hooker), in 1849, whilst on his way to Darjeeling, had, however, already discovered thin coal seams associated with carbonaceous shales containing remains of *Trizygia* and *Vertebraria*, plant fossils, characteristics of the Damodar Valley coalfields, but this information was not published until after Oldham's visit[2]. Later, the construction of the Northern Bengal State Railway made the investigation of this Damuda coal a matter of importance, and Mallet was deputed, at the urgent request of the Government of Bengal, to study the mineral resources of British Sikkim (as it was then called i.e., the Darjeeling Hill Territory) and the the Western Duars, in the field season of 1873-74. Mallet found several outcrops of coal seams, the more promising including an 11-foot seam in the Tindharia ravine, and a 7-foot seam in the Chirankhola *Nadi*. These seams dip into the hills at high angles (ranging from 40° to vertical), and the coal is very powdery and crumbly due to crushing. The coal proved to be a low volatile 'anthracite coal' of moderately good quality, and Mallet regarded it as probably belonging to the Raniganj series, though it is now thought to be of Baraker age. Mallet's work on these coal seams and on the other minerals is described in his memoir 'On the Geology and Mineral Resources of the Darjeeling District and the Western Duars' (*Mem. Geol. Surv. Ind.*, XI, pp. 1-96, 1875). It was thought by Thomas Oldham (An. Rep. for 1874, *Rec. Geol. Surv. Ind.*, VIII, p. 7) that there was some prospect of this Damuda coal being made serviceable by the adoption of suitable contrivances for the utilization of powdery coal. The Darjeeling coal is, however, still unworked, although a total of 7,237 tons was recovered between 1896 and 1900 from a colliery established at Daling[3].

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1 *J.A.S.B.*, XXIII, pp. 201-203 (1854).

2 '*Himalayan Journals*', I, p. 402 (1854). On an earlier page (pp. 8 & 9), Hooker draws attention, as a botanist, to the danger of error that may arise from using plant fossils from widely separate countries, with different climates, as evidence of contemporaneous existence.

3 R. R. Simpson, *Mem. Geol. Surv. Ind.*, XLI, p. 36 (1914).

This extension of the rocks of the Peninsular coal-bearing series to the Himalayan foot-hills is, of course, a matter of great geological interest in connection with the limits of what we now call Gondwanaland. Mallet in his memoir (*loc, cit.* p. 32) discusses the possibility of the existence of Damuda rocks below the Gangetic alluvium between Rajmahal and the foot of the Darjeeling Hills and suggests (p. 33)

> 'at some future epoch in the History of India, when her manufacturing industries shall have been fully developed, when the demand for coal shall have enormously increased, and the fields of the Damuda valley begin to show signs of exhaustion, it is quite conceivable that the winding engine and the cage will be seen in the midst of the alluvial plains of Bengal where an unbroken expanse of rice-fields now stretches to the horizon'.

Mallet also investigated the copper and iron ore deposits of the Darjeeling Himalaya. At the time of his visit, the mining and smelting of copper-ore (copper pyrites) was being pursued by the local inhabitants and by Nepalis at a number of places. Mallet describes at length both the deposits and the methods of mining and smelting. This activity has long come to an end, due no doubt partly to the difficulty of working in depth by primitive methods. The copper lodes occur in his Daling Series to be noticed later.[1]

During these investigations, Mallet prepared a geological map of British Sikkim (the Darjeeling District) and of the foothills to the Bhutan Himalaya to the east (the Western Duars, which form a part of the Jalpaiguri district). This work enabled him to lay the foundations of our understanding of the stratigraphy of this part of the Outer Himalaya. Besides the Tertiary beds (Nahans or Lower Siwaliks) and the Damudas, he separated the Darjeeling Gneiss[2], the Daling series of slates, schists, and quartzites, and the Baxa series of slates, schists, dolomites and quartzites. As the Gneiss and the Dalings were almost exclusively confined to the Darjeeling territory, and the Baxa beds to the Duars, Mallet found it difficult to decide the relationship between the Gneiss and the Dalings on the one hand and the Baxa beds on the other. But on one point he was quite

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[1] Modern attempts have been made to prospect the copper-ore deposits of the Darjeeling and Sikkim Himalaya. These have not yet led to success, but, as valuable lodes have been located, one cannot rule out the possibility of ultimate success, once the difficulties of prospecting under a cover of thick tropical vegetation, and of the high cost of transport, have been surmounted. See *Rec. Geol. Surv. Ind.*, XLVI, pp. 260-263 (1915).

[2] 'Sikkim Gneiss' on the map to Mallet's memoir but on page 39 he prefers the name 'Darjeeling' as the gneiss of Kanchanjunga in Independent Sikkim may be of different age. Auden in the map to his paper cited in the next foot-note treats the gneiss of Darjeeling and Kanchanjunga as the same and uses the term 'Darjeeling Gneiss'.

clear, namely that the less metamorphosed Daling beds underlay the more highly crystalline Gneiss, and also that no sharp junction separated the two, so that (*loc. cit.*, p. 42):

> 'All that can be done is to divide the less from the more altered strata on the large scale and it must be remembered that this is merely a provisional separation of convenience, as there is no evidence of any stratigraphical break'.

Later research confirms this absence of stratigraphical break[1].

But Mallet, like H. B. Medlicott in the North-Western Himalaya, was not prepared to recognise inversion, and therefore to him, since the Damuda beds dipped under the Dalings, the latter and the Sikkim Gneiss were both of post-Damuda age. He follows Medlicott in his explanation of the relationship between the Tertiary rocks and the older rocks under which they appear to dip, by the hypothesis that the line of junction (*loc. cit.*, p. 48)

> 'is primarily a line of original contact, possibly modified by subsequent faulting', and 'that the original limit of deposition of these rocks was a steeply escarped coastline, against which the muds and sands were banked'.

This line, is of course, what has later been regarded as the Great Boundary Fault of the Himalaya.

On the age of the Baxa beds, Mallet is doubtful; they may be oldest of all, but they bear some relationship to Medlicott's Krol Group. On the 1931 Geological Map of India, both the Dalings and the Baxa beds have been given the Dharwarian colour. But if they are of different ages, then the Baxa beds should be the younger, judging from Mallet's map and allowing for inversion of strata.

Singhbhum: From the Darjeeling foot-hills we can suitably step across the Gangetic plain to the north-east corner of the Indian Peninsula and review the work of Valentine Ball during this period of years. In 1868-69, in continuation of previous work in Manbhum, Ball made a study of Singhbhum and adjoining small states, and especially of the belt of old workings for copper which he traced for 80 miles. The results of this survey, of which a small portion was completed in 1874-75, when Ball was marching to examine the Raigarh-Hingir coalfield in Gangpur State, are given in the second part of his Memoir already alluded to (*Mem. Geol. Surv. Ind.*, XVIII, pp. 131-150, 1881). The accompanying map, which is on the scale of 4 miles to an inch, includes not only the parts of Manbhum and Singhbhum surveyed by Ball and his collaborators, but also the Jharia and Raniganj coalfields: this map is, in fact, one of the most important of our early maps,

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[1] J. B. Auden, *Rec. Geol. Surv. Ind.*, LXIX, pp. 161-164, 1935.

depicting, as it does on this scale, the geology of a very large area. The Singhbhum portion of the map has been a source of information to all subsequent workers, both geologists and mining men, in their studies of the mineral resources of Singhbhum: in particular, the prospecting of the copper belt in the present century by the Geological Survey of India has led ultimately to the formation of the present successful Indian Copper Corporation.

In this Memoir, the old crystalline and metamorphic rocks are arranged into two groups, Sub-metamorphic or Transition, and Metamorphic. It is the first group that contains most of the valuable minerals of Singhbhum, and this group is now thought in the main to correspond largely with sections of the Dharwarian rocks of Southern India. A complicated net work of basic dykes is represented as traversing the granitic rocks of the principal metamorphic area of Singhbhum, recalling the dyke system of Bundelkhund.

The Rajmahal Hills : In 1869-70, Ball and Ormsby were sent 'to revise and bring up to the existing state of knowledge of Indian geology the maps of Bhagulpur and Birbhum previous to final publication'. (An. Rep. for 1869, *Rec. Geol. Surv. Ind.*, III, p. 6). This included revision of the maps of the Rajmahal Hills by Ball where his attention was to be concentrated specially on the sub-trappean formations. From this work came his Memoir on the 'Geology of the Rajmahal Hills' (*Mem. Geol. Surv. Ind.*, XIII, pp. 155-248, 1877). In it, he notes (p. 158) that the geological survey of these hills was first commenced in 1852, with a foot—note i.e., 'the Geological Survey as at present constituted'. He disagrees completely with the views expressed by McClelland in his Report for 1848-49 concerning the relationship of the Rajmahal traps to the associated coal measure rocks of the Rajmahal series. One of the principal points of interest in the geology of these hills is the presence of numerous basaltic lava flows interbedded with sediments of the Rajmahal series, regarded as of Jurassic age. There seems to be no doubt that these basalts are lava flows and not intrusive sheets, and consequently that they must also be of Jurassic age and belong to an older period of basaltic extravasation than the Deccan traps, which, at their earliest, cannot be older than uppermost Cretaceous.

Chota Nagpur and the Valley: In the later years of this period, Ball worked westwards from Singhbhum into Chota Nagpur and Sirguja and into the Mahanadi Valley, to Sambalpur and the Talchir coalfield with the resultant production of papers in the Records on the Bisrampur Coalfield (VI ,pp. 25-42, 1873), the Raigarh and Hingir coalfields (VIII, pp. 102-121, 1875), and 'On the Geology of the Mahanadi Basin and its Vicinity' (X, pp. 167-186, 1877). It is in the latter paper (p. 180) that the term Sakoli Beds, for certain sub-metamorphic beds between Raipur and Bhandara, first makes its public appearance, although the existence of these beds had been previously noted by W. T. Blanford in an unpublished report. Ball's visit to the Talcher coalfield 'to investigate there-discovery of this field

by the Civil Officers of Orissa' (An. Rep. for 1876, *Rec. Geol. Surv. Ind.*, I., p. 3), and his penetration southwards into Kharial, Kalahandi and Bastar, caused him to notice (p. 183) some of the garnetiferous rocks that characterise my garnetiferous province in this part of India, though he does not draw attention to the marked difference in the abundance of this mineral between the crystallines to the north of the Talcher coalfield (practically no garnets), and those to the south of this field (abundant garnets).

South Mirzapur and North Hazaribagh : Amongst the various duties performed by Mallet during this period, from 1868 to 1876, were three that suited admirably his flair for mineralogy, for we must regard him as India's first mineralogist. The first of these was to make new maps of the southern parts of Mirzapur and adjoining parts of Rewah State, as a continuation of previous work in the Son Valley belt. This was in the 1870-71 and 1871-72 period, when Mallet also mapped the limits of the coal occurrences of Kota in the Singrauli coalfield (An. Rep. for 1871, *Rec. Geol. Surv. Ind.*, p. 2, 1872). He recorded then 14 outcrops of coal; but, perhaps because he did not publish an account thereof, this work has been overlooked completely by R. R. Simpson and C. S. Fox in their works on the coalfields of India and by K. P. Sinor in his 'Mineral Resources of Rewah State', pp. 58-60 (1923), all of whom notice the Kota coal. On the remainder of this work, Mallet reported in his paper 'Mineralogical notes on the gneiss of South Mirzapur and adjoining country', *Rec. Geol. Surv. Ind.*, pp. 18-23 (1872). This is the first important paper of a mineralogical nature published by the Geological Survey of India though there had been several small papers on specific mineral occurrences of economic value. Mallet notes that the Rehr valley offers to the mineralogist a tolerably rich field in comparison with the gneiss of many other portions of the country, and he lists the minerals of South Mirzapur according to their mode of occurrence. The most important mineral occurrence described in this paper is that of the now noted corundum bed of Pipra (which is in Rewah State), where there is found not only corundum in quantity of economic significance, but also green and white jade (tremolite), and the emerald green chrome-mica euphyllite.

In the following field season, 1872-73, Mallet was sent to North Hazaribagh, where new large scale maps had become available. His task was specially to study the crystalline and metamorphic rocks, whilst James Willson was engaged in transferring to the new maps the coalfield boundaries in the south of the same district. As Mallet's work was prematurely ended by his deputation in the following field season to the Darjeeling district and the Duars, and as he was never able to resume this work in Hazaribagh, it is a fortunate circumstance that he recorded the results of this work to date in 'Geological Notes on part of Northern Hazaribagh' (*Rec. Geol. Surv. Ind.*, VII, pp. 32-44, 1874). This is a paper of importance because it gives us much information on the crystalline complex of this part of India, of which no one else has yet given a consistent account.

Mallet's paper is unfortunately not illustrated by a map, but his field maps are preserved in the office of the Geological Survey of India. It is impossible to discuss this paper here in any detail, and all that we must say is that the author groups his rocks into metamorphic (gneiss with mica schist, dome gneiss, crystalline limestone, and with these, ores of lead and tin) and sub-metamorphic (Mahabar quartzite, mica-schists, and Bhiaura quartzite). He discusses the relation of the metamorphic to the sub-metamorphic rocks and finds no evidence of unconformity in the area studied, but this area is, in his opinion, too small for a safe conclusion to be drawn on this point. He also describes the pegmatites and the mica deposits, one of India's chief sources of mineral wealth. It was a great loss to our knowledge of the crystalline and metamorphic rocks of India that Mallet was never able to return to his work.

Mallet's third mineralogical task during this period was his work in the Museum (described later).

Satpura coal basin and the Gondwana System : Apart from supervising the work of his party, Medlicott seems to have spent most of the field season, from 1868-69 onwards, on problems connected with the coalfields until he took charge of the department, on the retirement of Thomas Oldham. In 1868-69, he set out to study the extent and stratigraphical relations of the several series of sandstones, etc. associated with the coal in Bengal as compared with those in Central India (*Rec. Geol. Surv. Ind.*, III, pp. 4 & 5, 1870) and, in pursuance of this object, he traversed the entire extent of country between Hazaribagh and Palamau on the east and Jubbulpore to the west, and thence went southwards to Nagpur and Chanda. The results of this tour are discussed by Oldham (*loc. cit*, III). Medlicott was able to establish, even more fully than previously had been done, the vast expansion and wonderful constancy in mineral character of the Talchir rocks, the base of the great coal-bearing series. He 'also brought forward additional proofs to show that, on the large scale, the present limits of these coal-measure fields coincide approximately with the original limits of deposition and are not the results of faulting, or even mainly of denudation'. This was a view long held by Hughes with reference to the Bengal fields that he had examined, and is expressed very clearly by Medlicott in his study of the Satpura coal-basin referred to later.

The results of his work on the coalfield problem are discussed by Medlicott in a series of papers between 1870 and 1873, of which the most important are his 'notes on the Satpura coal-basin' (*Mem., Geol. Surv. Ind.*, X, pp. 133-188, 1871) and his papers on the Mohpani (*Rec. Geol. Surv. Ind.* III, pp. 63-70, 1871), and Shahpur (Betul) (*op. cit.*, VIII, pp. 65-86, 1875) coalfields. In the first paper, Medlicott establishes the sub-divisions of the coal measures in the Satpura coal-basin, dividing the Mahadeva into three groups—Bagra (Upper), Denwa, and Pachmari (Lower), and the Damudas into two groups—Upper and Lower, the latter being the Barakars. The

Upper Damuda group, he divides into an upper Bijori horizon and a lower Motur horizon. In addition, he made in this report, before it was published, the most important nomenclatural proposal of all, namely that the coal-bearing series of India should be called the Gondwana system after the former Gond kingdom of this name, a kingdom that extended from Chanda northwards into the Satpuras. This proposal was not, however, included in the memoir as published; but once the term had been proposed it became current in the Survey and was used by H. F. Blanford in his 'Physical Geology of India[1]' and was eventually brought into print in the departmental publications by Feistmantel in 1876 (*Rec. Geol. Surv. Ind.*, IX, p. 28, 1876). Hitherto, in this history of the department I have refrained from using this very convenient and important term; but henceforward it will be suitable to speak of the Gondwanas.

W. L. Willson : Jhansi, Central India and the Central Provinces : Into his years of work on the Gondwana coalfields, Medlicott in 1870 , sandwiched the revision of the geological maps of the Jhansi, Lalitpur and Saugor districts prepared by W. L. Willson and others (An. Rep. for 1870, *Rec. Geol. Surv. Ind.*, IV, p. 2). This brings us conveniently to the work of W. L. Willson. Throughout this period of nine years Willson worked steadily in the districts of Saugor and Damoh in the Central Provinces, in Lalitpur, Jhansi, and Jalaun in the United Provinces (as far north as Hacket's ground in Gwalior), and in Bundelkhand and Rewah. Unfortunately, Willson appears to have been one of those unambitious men who are reluctant to put pen to paper so that there is no publication against his name in La Touche's Bibliography. The consequence is that for any knowledge of his work, we are compelled to refer to his maps filed in the office of the Geological Survey of India in Calcutta, to notices in the Annual Reports of the Superintendent of the Survey, and to references in the writings of others[2]. The ground surveyed by Willson during the years 1868 to 1876 was occupied by the Vindhyans and Deccan Trap in the south, and by the Bundelkhand Gneiss and alluvium in the north, with the Bijawars intervening. During this survey, he traced the remarkable series of trap dykes and quartz reefs that traverse the Bundelkhand Gneiss between the Gwalior beds in the north-west and the Bijawar and Vindhyan beds in the south-east. The Trap dykes were found to be younger than the quartz reefs but in no case were they seen to penetrate either the Vindhyans or the Bijawars (see *Rec. Geol. Surv. Ind.*, p. 4, 1872). Some of Willson's work was revision, necessitated by the provision of more detailed maps than previsiously had been available.

The Jubbulpore 'Bijawars' : During this period, C. A. Hacket was engaged on two main tasks. From 1869 to 1873, he surveyed in

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1 First published in 1873. In the third edition published in 1879, the work is restricted to Physical Geography and the term Gondwana does not appear.

2 For references to his work see La Touche's Index to Volume I to LIV of the *Memoirs*, p. 402; and to his Index to Volume I to LXV of the *Records*, pp. 717-718.

the Jubbulpore district and adjoining portions of Rewah, Narsingpur, and Hoshangabad. He has given no published account of this work so that we must refer to Thomas Oldham's annual reports, and to the paper written some years later by Mallet[1], illustrated by a geological map in which Hacket's work is incorporated. Amongst the strata mapped, is a wide stretch of 'Transition' rocks that he regarded as Bijawars, giving local names to the sub-divisions thereof (in descending order: Chanderdip, Lora, Bhitri, and Majhauli, as recorded by T. Oldham, An. Rep. for 1871: *Rec. Geol. Surv. Ind.*, p. 9, 1872). Hacket had, of course, already seen the typical Bijawars of Bijawar. Mallet, in the paper mentioned above, accepts Hacket's indentification without discussion, perhaps because his paper was concerned with minerals of economic interest—iron-ore, manganese-ore, aluminous laterite (*loc. cit.*, p. 113; the first discovery of bauxite in India), dolomite and fireclay. This absence of comments is perhaps strange, for the Jubbulpore 'Bijawars' are very different from the rocks termed Bijawar, lower down the Narbada Valley (Dhar Forest etc.), which Mallet had seen and determined as Bijawars (see W. T. Blandford's, *Mem. Geol. Surv. Ind.*, VI, p. 199, 1869). The difference will be understood on comparing the accounts of the two areas; it was also noted by the present writer, who has also visited both areas. The Jubbulpore and Narbada Valley rocks are probably an extension to the south-west of the Son Valley Pre-vindhyan rocks, which are shown on the 1931 Geological Map of India as in part Bijawar and in part Dharwarian. The same criteria applied to the Jubbulpore and Dhar Forest rocks has caused them to be coloured respectively as Dharwarian and Bijawar on the same map.

Hacket's other field of work, during this period, was the northern section of the Aravalli belt of ancient rocks ranging south-westwards from Delhi to Jaipur.

Hacket's work in the Gwalior region from 1864-65 to 1866-67 has already been mentioned. The results of this work are given in his 'Geology of Gwalior and vicinity' (*Rec. Geol. Surv. Ind.*, III, pp. 33-42, 1870) in which he introduced the term Gwalior series, dividing this into two groups; the upper thicker Morar group being composed of shales, ribbon jasper and hornstone, often ferruginous, with some limestone, and with four horizons of contemporaneous traps, and the lower, the Par group being composed of quartzites and some shales. The Par quartzite rests unconformably on the Bundelkhund Gneiss.

Hacket and the Aravalli Region: From Gwalior, Hacket went westwards into the Biana Hills to the east of Jaipur (*Rec. Geol. Surv. Ind.*, II, p. 28, 1869), and near the northern end of the Aravalli tract. In the following season, because of the failure of the crops in Jaipur and adjoining country, and the suffering of the population resulting therefrom,

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1 'On the iron-ores in the North-Eastern part of the Jabalpur district', *Rec. Geol. Surv. Ind.*, XVI, pp. 94-121 (1883).

Hacket was transferred to the Jubbulpore country to the work noticed above. It was not until 1874 that Hacket was able to return to the Aravalli region of Rajputana, when he mapped a large area of the country between Bhartpur and Jaipur. The rocks thus mapped, like those previously described from the Biana Hills, consisted chiefly of quartzites, with irregularly intercalated zones of schists, limestones and trappean rocks resting upon or against gneissic masses. According to Thomas Oldham (*Rec. Geol. Surv. Ind.*, VIII, p. 7, 1875):

> 'Mr. Hacket is disposed to adopt the name attached to the general range of these hills as a general inclusive name for the whole series of rocks, and to call them the *Aravali series*'.

After leave in Europe, Hacket returned to Rajputana, this time to Alwar in 1875 (*Rec. Geol. Surv. Ind.*, IX, p. 3) and he carried his boundaries as far as Jaipur during 1876 (*Rec. Geol. Surv. Ind.*, X, p. 6, 1877).

The results of Hacket's work over these several years are shown on the geological map accompanying his important paper entitled 'Note on the Aravali series in North-Eastern Rajputana' (*Rec. Geol. Surv. Ind.*, X, pp. 84-92, 1877). In this paper, the term Arvali (Aravali and Aravalli on the map) is applied to nearly all the exposures of pre-Vindhyan rocks west of the Karauli range of Vindhyans, with the exception of small areas of a schist series and of gneiss, which are regarded as pre-Aravali. He divides his Arvali series into three groups in descending order as Mandan, Ajabgarh, and Alwar: the Alwar group he divides into upper Alwar quartzites and Lower Raialo limestone and quartzite.

This comprehensive original application of the term Arvali proved to be an unfortunate one. For, after further work to the southwards in which, during the years 1877 to 1881, he carried his mapping of the Aravalli ranges as far south as Chitor. Hacket discovered that his original Aravali series was not only comprehensive but composite, with several examples of unconformity within. The results of this work are described in his second Aravali paper 'On the Geology of the Arvali region, Central and Eastern' (*Rec. Geol. Surv. Ind.*, XIV, pp. 279-303, 1881). In this paper, he recognises that his original Arvali series contains two major formations, for which separate names are needed (p. 281). So, he proposes to exclude the Alwar quartzites from the Arvali series, and to call these quartzites and their associates in the Mandsaur hills and elsewhere the Delhi series, 'retaining the name of the Alwar quartzites for the lower member of the series'. He evidently still intended to preserve the term Arvali for application to most of the rocks forming the Aravalli Hills, for he writes:

> 'The rocks occurring in the Arvali range consist of gneiss, mica and hornblende schists, and limestone, mostly in the form of marble, the representatives here of the Arvali series, and quartzite probably the Alwar quartzite'.

The map accompanying his paper shows separately the areas he regards as Arvali and those he regarded as Delhi.

Detailed surveys over many years during the present century by the Rajputana party, first under Mr. C. S. Middlemiss and later under Dr. A. M. Heron, have shown that in spite of the increasing severity of metamorphism in the Aravalli Range as one proceeds to the south-west, one can show that most of the rocks in this range must be included in the same series as the ribs of Alwar quartzites, with which they form part of a giant synclinorium. They can, thus, all be treated as Delhis. Alternatively, one may say that the rocks treated by Hacket in his second paper as Delhis were only a less metamorphosed form of such of his Arvali rocks in the Aravalli Range.

There were two possible methods of rectifying this nomenclatural muddle caused really by Hacket's failure to recognise the progressively severe metamorphism to the south-west and the complications introduced by inversion. One method was to follow Hacket's evident intention in both papers and make the choice that ensured that the term Arvali was applied to the rocks that constituted the body of the Aravalli Range. This would have meant the abandonment of the pleasant term Delhi, and have required the proposal of a new name for the older rocks that underlay the synclinorium of the Aravalli Range (Blanford's term Champaner was available, though this was not then known). The other method was to retain the term Delhi and pursue it to its remorseless metamorphic conclusion. The latter is the choice that was made, and as a result the Aravalli Mountains do not consist in the main of the rocks of the modern Aravalli series, but of those of the Delhi series, whilst the Aravalli series and gneisses occupy the low ground flanking the Aravalli Range. The term Aravalli has thus become inappropriate: but this does not matter because the term Champaner, which has priority, is available, and we should now regard the Aravalli tract as containing two important metamorphic systems, Delhi and Champaner. It is amusing to speculate on what solution to this tangle of nomenclature would have been found by the biologist if stratigraphers used a binomial method for their formations. Giving full value to the rules of priority, we may suggest that the upper system would have been called *Arvallius delhii* and the lower system *Champaneerus aravallii* !

I have not attempted in this discussion to deal with Hacket's Raialo beds regarded by him originally as a section of his Alwar group. The Raialos are now regarded as an additional system between the Delhis above and the Aravallis below[1].

[1] For a modern exposition of the stratigraphy of Rajputana see Dr. A. M. Heron's Synopsis of the Pre-Vindhyan Geology of Rajputana. *Trans. Nat. Inst. Science of India*, I, pp. 17-33(1935). In the map attached to this no portion of Hacket's original area of the Arvali series north of the Banganga river is shown as belonging to the modern Aravalli system. Instead, it all belongs to the two divisions of the Delhi system and to the Raialo series.

In this synopsis 'Dr. Heron mentions (p. 18) that the modern work on North-Eastern Rajputana had established that the views given in Hacket's earlier (1877) paper were correct, and that he was subsequently led into error' by a certain lithological similarity of part of the Ajabgarh series to the Aravallis, and by the prevalence of inversion and by the much more complex structures in the country treated of in his 1881 paper.

The Punjab : In the Salt Range, with its arid climate, its magnificent sections unobscured by tropical vegetation, its succession of richly fossiliferous formations, and its salt deposits, India possesses a spectacular and world-famous attraction for geologists and travellers, a region that was bound to challenge Thomas Oldham to action as soon as this could be arranged. With the completion of Wynne's work in Cutch, Oldham was able to initiate a careful examination of the Punjab by sending Wynne to the Salt Range. This was in the winter of 1869-70, during which Wynne surveyed the eastern portion of the Range. In the following season, 1870-71, he surveyed the western and in 1871-72, the country to the north as far as Attock and Hasan Abdal. To help Wynne on the palaeontological side, Dr. W. Waagen, recently recruited to the Department, was also sent to Punjab, to study the relations and mode of occurrence of the fossils of the Salt Range (An. Rep. for 1871, *Rec. Geol. Surv. Ind.*, V, p. 2). In addition, Wynne and Waagen made an examination of Sirban Hill (△6243 ft.) near Abbottabad (*Mem. Geol. Surv. Ind.*, IX pp. 331-350, 1872). The interest of their joint paper lies in the comparison made between the geology of a mountain lying to the south-west of the 'first great crystalline axis of the Himalaya' (*loc. cit.*, p. 349) and that of Spiti on the north-east side thereof, with the geology of Kashmir, lying between the two, so little known. A comparison is made between the formations of Sirban Hill and Stoliczka's Spiti succession. The term Attock Slates is introduced in this paper, presumably by Wynne.

Trans-Indus Salt Region, Kohat : In 1873-74, Wynne commenced the examination of the Trans-Indus Salt Region, and at his special request, Dr. H. Warth, in Charge of the Pind Dadunkhan Salt Mines in the Salt Range, joined him, so as to form practical estimates of the commercial value of the salt deposits (An. Rep. for 1874, *Rec. Geol. Surv. Ind.*, VIII, p. 3). During the recess season of 1874, Wynne completed his report on 'the Trans-Indus Salt Region in the Kohat District' (*Mem. Geol. Surv. Ind.*, XI, pp. 105-295, 1875) and was also engaged in revising his report on the Salt Range, which was not actually published until 1878 ('on the Geology of the Salt Range in the Punjab', *Mem. Geol. Surv. Ind.*, XIV, pp. 1-313, 1878). These two studies, with his memoir on the geology of Cutch, place Wynne in the first rank of Indian geologists.

The Salt Range : Wynne's Salt Range memoir of 1878 must be regarded as one of our classics, since it lays securely the foundations of our knowledge of this famous range and of the stratigraphy of this part of India. In discussing the numerous writings of previous workers and visitors, Wynne pays tribute to the work of Fleming (see Chapter II) and also to that of Theobald. Wynee gives (*loc. cit.*, p. 69) a list with thicknesses of 15 groups of strata, ranging from Post-Tertiary down to his *Obolus* or *Siphonotreta* beds regarded as Silurian, and to the underlying Purple sandstone and the basal Saline Series, to both of which no age is attributed. As a result of the subsequent palaeontological studies by Waagen of the collections of Salt Range fossils made by himself and Wynne, and by others (*Pal. Ind.*, 1879 to 1895), it has become necessary to modify the ages ascribed

by Wynne to some of these groups. Thus the *Obolus shales,* later called the *Neobolus shales,* were shown by Warth's later discovery therein of trilobites to be of Cambrain age[1]. The Carboniferous beds were found to include Permian strata (the Productus limestone). Further, the Olive series, regarded by Wynne as Cretaceous, was later shown by Warth[2] to be composite, the upper portion, containing *Cardita beaumonti,* being Upper Cretaceous, and the Lower portion, containing *Conularia* and other Carboniferous fossils being equivalent to the Speckled Sandstone, both containing glaciated pebbles and being equivalent to the Talchir boulder beds.

In view of the modern controversy concerning the age of the Saline Series, it is important to quote the passage containing Wynne's views (*loc. cit.*, p. 73):

> 'As to age, the salt marl has been referred to Triassic, New Red Sandstone or Permian, Miocene or Pliocene, but it is now known, from the way in which it passes below the overlying beds, to be not newer than Silurian—a fact depending upon the discovery of *Obolus* or *Siphonotreta* in the group No. 4. Beyond this its place cannot be as yet more definitely fixed'.

No. 4 is a misprint for No. 3, and the Silurian beds have been since shown to be Cambrian; and therefore, on Wynne's mapping, the Saline Series and the overlying Purple Sandstone cannot be younger than Cambrian.

One of the arguments that has often been adduced in favour of a Tertiary age for the salt of the Salt Range is that the Kohat salt is Tertiary. In his earlier memoir, (XI, p. 141), Wynne discusses the two salt series in the following passages:

> 'It is certainly peculiar that in such close proximity here there should be two salt series of great thickness and extent, one not younger than silurian age, and the other associated with nummulitic rocks, a fact which is of itself suggestive of strange conditions from earliest times having affected the region of the Upper Punjab if it does not point to an ancient local and recurring source for the mineral'.

> 'The differences pointed out in the character of the salt itself, contrasted with that of the Salt Range, together with the diversity marking the whole geological section in the two regions, and the difficulty of finding and adequate explanation of the absence here of the great overlying Salt Range series, seems sufficient to warrant the conclusion that the rock-salt deposits of these two regions are of entirely separate age: while the details given, and to follow indicate that the Kohat salt, if not, as appears likely absolutely Eocene, is at any rate, not much older than the base of the nummulitic formation'.

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1 *Records*, XXII, p. 153 (1889) and C. S. Middlemiss, XXIV, p. 24 (1891). It must not be overlooked that Waagen, in opposition to Wynne for a time regarded the *Obolus* or *Neobolus beds* as of Lower Carboniferous age. See *Records*, XXII, p. 155.

2 See Wynne, *Records*, XX, p. 117 (1887) and Waagen, *Records*, XIX, pp. 22-38 (1886).

The differences alluded to above are discussed by Wynne on pages 134 and 135 of his Kohat memoir, an important one being that of colour grey for the Kohat salt and its associated gypsum, and red or orange for the Salt Range salt and gypsum. Again quoting (*loc cit.*, p. 135):

> 'In a word, the salt deposits of the two regions are so strikingly unlike that, even small samples, if not reduced to powder, are declared capable of being sworn to with confidence by those whose duty it is to prevent the Kohat salt from entering the country on the other side of the Indus'.

The recent re-survey of the Salt Range by Dr. E. R. Gee, on maps of a larger scale than were available to Wynne, has confirmed, on stratigraphical grounds, that the Saline Series of the Salt Range is of Cambrian age or older.

It is convenient here to mention two investigations in the Punjab by H. B. Medlicott.

Umballa borehole : The insufficiency of water in the plains at such large military stations as Umballa had long been a source of anxiety; and Medlicott, after his examination of the Sub-Himalayan rocks some years previously had urged the importance of seeking this much-needed supply in the water-bearing beds that must exist under the alluvial country along the foot of the hills (*Mem. Geol. Surv. Ind.*, III, Pt. 2, p. 182, 1859). Consequently, when a deep hole was bored at Umballa in 1869, the Geological Survey were greatly satisfied that this trial proved to be successful. (see An. Rep. for 1969, *Rec. Geol. Surv. Ind.*, p. 3).

Tertiaries of Jummu: In the winter of 1875-76, after F. Drew had ceased to be geologist to the Maharaja of Jammu and Kashmir, Medlicott again took the field in the Punjab, this time accompanied by Theobald and Lyddekker, in order to begin a revision of the Tertiary rocks of the North-west and the Punjab (*Records*, IX, p. 2, and X, p. 3), this revision taking the form of an 'outline-survey of the broad band of tertiary deposits flanking the Pir Panjal in Jammu territory, thus connecting previous work in the Cis-Ravi and Trans-Jhelum regions', done respectively by Medlicott and Wynne[1].

This Survey brought Lydekker[2] in contact, in the field, with the vertebrate remains of the Siwaliks, collections of which he had already commenced

[1] See H. B. Medlicott's 'Note upon the Sub-Himalayan Series in the Jammu (Jumoo) Hills', *Records*, IX, p.49 (1876).

[2] There appears to have been some doubt on the correct spelling of his name. In his first paper, in *Records* VIII he used the form Lyddekker, but in the first two papers in *Records* IX and also in Medlicott's Jammu paper in the same volume the spelling is Lydekher. Thereafter, in the same volume the first form is again used. He is reecorded as natural history Secretary of the Asiatic Society, 1878 with the spelling Lydekher. See Centenary Review *A. S. B.*, p.93.

to study in Calcutta, and which had first been brought to notice in the past by Cautley and Falconer.

The Kumaon Lakes : In addition, this trip enabled the party to visit the lakes of Kumaon, which according to speculations of Theobald were of glacial origin[1]. As a result of this joint inspection, the conclusion formed was that the so-called moraines are only the remains of diluvial deposit that once covered the valley (*Rec. Geol. Surv. Ind.*, IX, p. 36). Valentine Ball visited these lakes on holiday in 1877, and wrote a paper on their origin (*Rec. Geol. Surv. Ind.*, XI, pp. 174-182, 1878). Ball is against a glacial origin, and favours a combination of the closing of valleys by landslips, with the possibility of faulting at Nani Tal.

Some years later, C. S. Middlemiss made a detailed survey of the hills station of Naini Tal, in order to give advice on the landslips that periodically afflict this health resort. He decided that the lake had a rock outlet and that its origin might be due to a combination of faulting and the solution of limestone (*Rec. Geol. Surv. Ind.*, XXIII, p. 228, 1890), but this explanation was not intended to apply to the remaining lakes. The present writer visited these lakes on holiday in 1906 and saw abundant evidence of the activity of landslips[2]. Undue space has, perhaps, been given to these lakes because lakes are so rare in the Himalaya, in contrast to the state of affairs in so many mountainous regions.

The Yarkand Mission : The untimely death of Dr. Stoliczka in 1874 on his return journey from the Yarkand Mission, has been mentioned earlier. Fortunately, he was able to despatch to Calcutta a few small notices of the nature of progress reports, and these form the basis of five short notes in the *Records* (four in volume VII, and one in volume VIII). The fourth of these on a visit to the Chanderkul, Thian Shan range, is dated Kashgar, 16th January, 1874, about 6 months before his death. The fifth paper (*Rec. Geol. Surv. Ind.*, VIII, p. 13) records travels in February, 1874, when the ground was much obscured by snow. This, no doubt, explains partly the sub-title to the paper *Veni sed non vidi.*

It fell to W. T. Blanford to examine Stoliczka's collections[3].

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[1] 'On the former extension of Glaciers within the Kangra district'. *Rec. Geol. Surv. Ind.*, VII, pp. 86-98, (1874).

[2] It is, perhaps, amusing to visualise geologists visiting these beautiful lakes, sometimes on holiday, and throwing at one another theoretical stones, either glaciated or landslipped. According to Ball ('Jungle life in India', p. 537), at Malwa Tal even the monkeys take part in the sport.

[3] The results thereof are given in the section of Geology, pp. 49 of 'Scientific Results of the Second Yarkand Mission' based upon the collections and notes of the late Ferdiaand Stoliczka, Ph. D., (1878), Calcutta. An abbreviated account of Stoliczka's work in the Karakoram, the Kuenlun range, and the Pamir, will be found in the Mannual of the Geology of India, pp.652-658 (1879).

The Bombay Party *Cutch :* We have recorded that on his arrival in India in 1862, Wynne was attached to the newly formed Bombay Party under Dr. W. T. Blanford, with whom he was engaged in the survey of portions of the Bombay Presidency in Western India. On the completion of this work, Wynne was absent from India on medical certificate for the whole of 1866-67 and did not rejoin until towards the end of 1867. In 1868, as Blanford was absent with the Abyssinian Field Force, Wynne was placed in charge of the Bombay Party, as officiating Deputy Superintendent, preparatory to undertaking a regular survey of Cutch with the aid of Fedden. The maps available were very inferior, but Wynne was a good draughtsman and prepared a general map from all available material, adding further information in the field during the course of the geological survey. Wynne undertook the examination of the plant beds and the associated Jurassic marine beds, whilst Fedden examined the parts occupied by Tertiary rocks. They completed this survey in 1869, after which Wynne went to the Salt Range as related above, whilst Fedden joined Blanford and worked under his instructions in the Chanda and Wun district in the Central Provinces, which appear from the logic of events to have become part of the ground of the Bombay Party. The results of the work in Cutch are contained in a memoir by Wynne[1], a memoir which has served ever since as the basis of our knowledge of the geology of Cutch. In his memoir, Wynne divides the Jurassic strata into two groups, upper and lower, these terms being of local application. His memoir also contains an interesting discussion on the earthquakes of Cutch and the formation of the Allah Bund. In 1871, Stoliczka visited Cutch specially to study the occurrence of the Jurassic fossils and make further collections therefrom (An. Rep. for 1871, *Rec. Geol. Surv. Ind.*, V, p. 11). As a result he divided the Jurassic rocks into four, and allotted the now familiar names Patcham, Chari, Katrol and Umia, the uppermost beds of the Umia ranging into the Lower Cretaceous. The Cephalopoda of Cutch were described by Waagen in 1873 to 1876[2]; but the study of the remainder of the rich collections of fossils from Cutch made by Wynne, Fedden and Stoliczka, has been continued in successive volumes of the same Series by J. W. Gregory, (II Echinoidea and Corals, 1893 and 1900), F. L. Kitchen (III Brachiopods and Lamellibranchs, 1900 and 1903) and L. R. Coz (IV Lamellibranchs, 1940). Taking Waagen's determinations, the range of the Jurassic of Cutch is from Bathonian to Portlandian (with Lower Cretaceous, Aptian). Beds containing plant remains occur to a small extent in the Katrol beds, but mainly in the Portlanadian and in the Lower Cretaceous beds of the Umia series, and form a link with the Gondwanas by the affinity of some of the plant Fossils with those of the Jabalpur series.

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1 'Memoir on the Geology of Cutch' to accompany the Map compiled by A. B. Wynne and F. Fedden, during the seasons of 1867-68 and 1868-69 (*Mem. Geol. Surv. Ind.*, IX, pp.1-295, 1872).

2 *Pal. Indica.*, Series IX, Vol. I. The names given by Stoliczka were used in a M.S. report and adopted by Waagen in this work

Dr. Feistmantel, on his arrival to join the Geological Survey in 1875, took up the description of the Fossil Floras of the Gondwana System in a number of volumes and parts of the *Palaeontologia Indica.* His first contribution thereto was on 'The Jurassic (Oolitic) Flora of Kach[1]. Feistmantel points out that there is a '*Palaeontological contradiction* (*Rec. Geol. Surv. Ind.*, IX, p. 29) between the evidence from the animal and the plant remains the plants, which are from a higher horizon indicating a somewhat greater age than the animals from a Lower horizon. The uppermost plant beds of the Umia series have since been regarded as Upper Cretaceous in age, so that the contradiction seems now to have been resolved.

Central Province, Hyderabad and the Godavari Valley: On the termination of this field work with the Abyssinian Field Force in 1868, already alluded to, Blanford was sent to Europe to work out the results thereof, and did not return to India until November, 1869, when he resumed charge of the Bombay party from Wynne. He appers to have been joined in Bombay by Fedden, and together they resumed surveying in the Berars and in Chanda in the Central Provinces. But before the season was finished Blanford was specially directed to the Korba coalfield near Bilaspur, and from thence he traced the continuation of the Gondwana rocks far to the east into Udaipur and Jashpur[2]. He was also able to examine the vein of galena at Chicholi near Raipur. In the following season, 1870-71, Blanford mapped the Gondwanas in the Godavari Valley, both in the Nizam's Dominions and in the Godavari district, Madras, where boring was carried on for coal at Damagudiem. Later in the season, Blanford continued the general mapping southward, especially of the Kamthi sandstones, nearly to Ellore. This work of Blanfords's is summarised in a series of short papers in Volumes III to V of the *Records.* After this Blanford was sent to Sind and then to Parsia, and he appears never to have returned to the Godavari Valley. As will be seen below, he left this tract one season too early.

Ice-Scratched Pavements: From 1870 to 1874, Fedden was employed in the Survey of Wun and Chanda, and in parts of Hyderabad near Chanda, partly in association with Hughes in the Wardha Valley coalfields. During this work, the very season after Blanford's departure, Fedden made one of the most interesting and important discoveries in the history of the Department. The Geological Survey of India had long since accepted Blanford's view based on his work in Orissa in 1855-56, that the Talchir boulder beds were of glacial origin. But, the hypothesis had lacked the confirmation of other evidence, such as the discovery of an ice-scratched pavement. It is the latter that Francis Fedden had the good fortune to

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1 *Pal. Ind.*, Series XI, Vol. II, Pt. I, pp. 1-80, 1876. See also *Rec. Geol. Surv. Ind.* IX, pp.29-34, 1876.

2 See An. Rep. for 1870. *Rec. Geol. Surv. Ind.* IV, p.13

find in January, 1872, in Hyderabad territory, near Irai, on the bank of the Penganga river. Thomas Oldham visited the place shortly after, and gave notice of the discovery in a foot-note to Blanford's memoir on the geology of Nagpur, then in the press. (*Memoirs*, IX, p. 324, 1872).[1]

Fedden later described the occurrence himself after a second visit in 1874, in a paper entitled 'On the evidences of ground-ice in tropical India, during the Talchir period' (*Rec. Geol. Surv. Ind.*, VIII, pp. 16-18, 1875). Essentially, the find consisted of a boulder bed containing polished and grooved boulders resting on a sloping pavement of hard Penganga limestone scored in long parallel lines wherever the surface had been exposed by the recent removal of the overlying rocks[2].

Wardha valley coalfield : In the winter of 1868-69, Dr. Oldham had at his disposal Mr. Mark Fryer specially appointed as Mining Specialist. After an introduction to Indian coral strata under Hughes in the Karharbari coalfield, Fryer was sent to Chanda where boring plant had been despatched from England for the purpose of determining the extent and character of the coal known to exist there (An. Rep. for 1868, *Rec. Geol. Surv. Ind.*, II, p. 29). In November, 1869, Oldham himself went to the Central Provinces to control the operations being conducted by Fryer with the friendly cooperation of Major Lucie-Smith, the Deputy Commissioner of Chanda. In the winter of 1869-70, when Blanford was back in the Chanda country, Hughes was sent to study the coal bearing rocks of East Berar and Chanda and so must be regarded as having joined this Bombay Party. Hughes continued to work in this region until 1873, surveying with the help of Fedden and controlling the boring operations, until these were transferred to the Central Provinces Government on April, 1870. The results of Hughes's investigations are given in his important memoir on 'The Wardha Valley Coalfield' (*Mem. Geol. Surv. Ind.*, XIII, pp. 1-154, 1877). Under this term, Hughes groups several areas of Barakar rocks that have since been dignified with names as separate coalfields, of which Warora, Ghugus, and Ballarpur in the Central Provinces, and Sasti in Hyderabad, are the best known. Hughes gives a tabular statement (*loc. cit.*, p. 9) of the Upper and Lower Gondwana strata from Bengal to Cutch. He introduces a new term

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[1] In this foot-note Oldham in so full of enthusiasm for this 'wonderful confirmation of Mr. W. Blanford's original supposition as to the mode in which this boulder bed was, in places at least, accummulated', and of his reget that Blanford could not himself announce the discovery because of his engagement on the Baluchistan-Persia boundary survey, that he (Oldham) omits to mention the name of the discoverer. This seems strange especially as the discovery was not mentioned in the Annual Report of the Survey for the year 1872.

[2] The exposure is situated about 10 miles W.S.W. of Chanda and has, of course, since been visited by other geologists, of whom Sir T.W. Edgeworth David and Professors A. P. Coleman and Dr. F. S. Moore may be mentioned. The writer acted as guide to Coleman and Moore during their joint visit. See Coleman's 'Ice ages: Recent and an ancient' pp. 104-108 (1926) for an account of this locality.

Kota-Maleri for the Upper Gondwanas of the Wardha Valley, these two localities being in the Pranhita Valley to the south. These strata are now regarded as including two stages, the Upper Kota beds resting on the lower Maleri beds. The Kota beds contain fossil fish discovered by Dr. A. M. Walker in 1850[1] and Dr. T. L. Bell in 1851[2], and plants discovered by Hughes and King[3]: whilst the Maleri beds contain fish teeth and reptilian bones discovered by the Rev. Stephen Hislop in 1859[4]. As in Cutch, there is a palaeontological contradiction between the ages for the Kota & Maleri beds as indicated by their fauna and flora[5].

Besides a one-inch geological map of the Wardha Valley coalfields in two sections, Hughes's memoir contains a map on the scale of 4 miles to an inch of a large portion of this part of India by Fedden and himself, on which are shown the Deccan Trap, Lametas, Gondwanas, Vindhyans, and Metamorphics. The Gondwanas are divided into four sections—Kota-Maleri, Kamthi, Barakar and Talchir. The Vindhyans[6] are divided into three sections—an upper sandstone group, a middle shale group and a lower limestone group. Hughes did not pretend to be an authority on these supposed Vindhyan rocks, and, later, King who had been both areas, identified the two lower divisions (the Penganga beds) with the Pakhal beds of the Godavari Valley equivalent of his Cuddapah system, leaving only the sandstone group of Hughes as Vindhyans, and equivalent to the Sullavais of the Godavari Valley. On the 1931 edition of the Geological Map of India, these old beds (Puranas) of the Wardha, Pranhita, and Godavari valley have been coloured on this basis.

In the economics chapter of his Wardha valley memoir, Hughes gives estimates of the quantities of coal in some of the fields, totalling to over 2,000 million tons, of which, of course, only a portion can be regarded as available. The analyses (by Tween) of the coal shows that whilst much of it is of fair quality it is non-coking. The best fuel appears to be that of the Sasti field, some of it comparing favourably with first class coal of the Raniganj field.

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1 *Q. J. G. S.*, VII, pp. 272-273, 1851.

2 *Op. cit.*, VII, pp.230-233, 1852.

3 *Mem. Geol. Surv. Ind.*, XIII, p. 86, 1877.

4 T. Oldham, *Mem. Geol. Surv. Ind.*, I, p. 295, 1859.

5 See 'Mannual of the Geology of India' I, pp. 100-102, 1879.

6 The shales were first described by Blanford and referred to as the *Pem shales* or *Pem beds* (see *Memoir*, XVIII, p. 221) after the Pem or Penganga river : whilst by Mallet the sandstone is referred to as the *Pranhita sandstone* evidently using a provisional term of Blanford's, and the shales and limestones as the *Pein Gunga shales* and *limestone* (*Memoir*, VII, pp. 124—125, 1871): the latter have become the *Penganga beds*, the spelling now used. See also *Memoir* VIII, p. 288. The term *Pranhita sandstone* is not mentioned by King in his 'Geology of the Pranhita Godavari Valley' (*Memoir*, XVIII, 1881), and has never advanced beyond the provinsional status mentioned by Mallet.

Lohara Iron-ore: The non-coking character of the coal is unfortunate because of the existence of enormous deposits of rich iron ore (70% Fe) in the crystalline area to the east of the coalfield belt[1]. Hughes gives a brief account of these deposits in his memoir, but reference should b e made to his note of 1873[2] in which he becomes lyrical upon the splendour of the Lohara deposit:

> 'The view presented by such a mass as that at Lohara, exclusively made up of almost pure specular iron, it does not fall to the lot of many men to see surpassed; and those who posses the opportunity of visiting this place ought to do so, and carry away with them the remembrance of having looked upon one of the marvels of the Indian mineral world'.

Sind: The importance of examining the Tertiary rocks of Sind, in order to help with the understanding of the Tertiaries of other parts of India, had long been evident. A second factor that made such a survey so necessary was that the magnificent figures and descriptions of Indian nummulitic fossils given by D'Archiac and Haime in their '*Description des Animoux Fossiles du Group Nummulitique de l'Inde*', published in Paris in 1853, lost half their value because the exact position in the series of beds from which the different fossils had been obtained was unknown. The majority of the fossils had been procured in Sind.

In 1863, W. T. Blanford had visited Lynyan and Ranikot (*Mem. Gol. Surv. Ind.*, VI, pp. 1-15, 1867): and in 1869 and 1871, he had been directed to undertake the examination of Sind; but in each case more pressing work arose (coal in Chanda in 1869 and Seistan in 1871). During the working season of 1874-75, however, Blanford and Fedden made a general examination of the province, and this work was continued during 1875-76, and 1874-77. The principal results of their first season's work are given in a paper by Blanford (*Rec. Geol. Surv. Ind.*, IX, pp. 8-22, 1876) in which the author shows that the Tertiary beds of Sind range in age from Lower Eocene to Pliocene. To the various divisions recognised, ranging from Infra-nummulitic to Supra-nummulitic and Siwalik, he allotted the new well-known names Ranikot, Kirthar, Nari, Gaj and Manchhar, the latter being regarded as the equivalent of the Siwaliks.

The full and considered results of this survey of Sind are contained in another of our classic memoirs, namely Blanford's 'The Geology of Western Sind' (*Mem. Geol. Surv. Ind.*, XVII, pp. 1-196, 1879) in which full recognition is given to Fedden's work and which is followed by a note by Fedden 'on the distribution of the Fossils described by Messrs. D' Archiac and Haime in the different Tertiary and Infra-Tertiary Groups of Sind' (*op. cit.*, pp. 197-210). This note of Fedden consists of a tabular statement

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[1] Originally brought to public notice by Hislop and Hunter in 1855 : *Q. J. G. S.*, XI, pp. 380-381.

[2] *Rec. Geol Suvr. Ind.*, VI, p. 78, 1873

allotting to their respective stratigraphical groups the fossils described by the French palaeontologists and satisfies one of the objects of the survey.

Age of the Decan Trap : The completed survey recognised not only the Tertiary strata named in the preliminary paper of 1876, but also (*loc. cit.*, p. 32) the existence in the Laki range below the Ranikot beds, of rocks regarded as Cretaceous consisting of hippuritic limestone overlain in turn by sandstones and *Cardita beaumonti* beds. The sandstones are regarded as Cretaceous, and the *Cardita beaumonti* beds as Upper Cretaceous, or as intermediate between Eocene and Cretaceous. Between the *Cardita beaumonti* beds and the overlying Ranikot beds, a band of basaltic lava ranging in thickness from 40 to 90 feet, and consisting of two lava flows in places, was traced for 22 miles. In addition, another bed of basalt was found interstratified in the sandstone underlying the *Cardita beaumonti* beds, and at about 600 to 800 feet below the upper basalt.

There has been so much controversary in recent years about the age of the Deccan Trap formation that it is important to quote Blanford's views on the ages of these traps of Sind (*loc. cit.*, p. 37)[1].

> 'The evidence that this band of basaltic rock is interstratified and not intrusive, is ample; throughout the whole distance the trap is found in precisely the same position between the lowest beds of the Ranikot group and the highest cretaceous strata, and apparently perfectly conformable to both. The close resemblance in mineral character and the similarity of geological position at the base of the tertiary beds show that this band must be, in all probability, a thin representative of the great Deccan and Malwa trap formation, and the occurrence of a second bed at a lower Horizon, interstratified with rocks of Cretaceous age, tends strongly to confirm the inference drawn from the relations of the traps to cretaceous and tertiary rocks in the Narbada valley, that the great volcanic formation of western India must be classed in part, at all events, as upper cretaceous'.

Great Indian Desert : Early in 1876, Blanford interrupted his work in Western Sind to make an important trip across the desert, east of the Indus through Unarkot and Barmer to Jodhpur and back through Jaisalmir, thus gleaning information on a part of Rajputana hitherto almost unknown geologically[2]. On this trip he met *Jaisalmir limestones* and *Balmir* (*Barmer*) *sandstones* of Jurassic age, the *Jodhpur sandstones* of suggested Vindhyan age, and the *Malani rhyolites*, but he did not get as far as Hacket's Arvali ground. Between the Malani beds and the Jodhpur sandstones he also found a series of shales and boulder beds, the latter containing in one place near Pokaran, boulders of Malani rhyolites resting on a grooved and striated pavement. He regarded these boulder beds as older than the Vindhyan sandstones but later work (1886) by R. D. Oldham

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[1] See also *Rec. Geol. Surv. Ind.*, XI, p. 165, 1878.

[2] 'Geological Notes on the Great Indian Desert between Sind and Rajputana' *Rec. Geol. Surv. Ind.*, X pp. 10-21 (1877).

leads to the view that these beds are of Talchir age. It seems specially pleasing that Blanford should himself have discovered one of the two Talchir ice-scartched pavements known in India.

The Madras Party

Upper Gondwanas of Guntur and Ongole: At the beginning of this period, the Madras Party consisted, as before, of C. A. Oldham (in Charge), King and Foote, with Foote on leave on medical certificate. Oldham and King continued the survey of the northern end of the basin of sedimentary rocks in the Karnul, Kistna, and Guntur districts. In an attempt to complete this, Oldham stayed out in camp in the Jaggayyapeta neighbourhood in the Kistna district until the onset of the monsoon in the middle of June, 1868 frustrated him. On his march back to Madras from Bezwada, he examined several occurrences of sandstone in the Guntur district and noticed their similarity to the Sripermatur beds of Madras; and to him must be given the credit for the discovery of Upper Gondwana beds in this part of India. He went on furlough in November, 1868 and died in April, 1869, as has been already noticed (An. Rep. for 1868, *Rec. Geol. Surv. Ind.*, II, pp. 30-31).

The Cuddapah Basin : In 1869, King (who had been appointed Deputy Superintendent for Madras on 15th November, 1868) and Foote completed the survey of the Cuddapah Basin. As Charles Oldham had died it fell to king to write the account of the Cuddapah Basin, which, being surrounded on all sides by the older Archaean crystallines, is one of India's most individual geological units. The outcome of King's labours is another of India's geological classics, entitled 'on the Cuddapah and Karnul Formations in the Madras Presidency'[1]. This memoir is illustrated with delightful plates of the scenery, drawn by King, and lithographed by Schaumburg, as well as by numerous text figures of scenery and sections. The accompanying geological map is on the scale of 16 miles to an inch, the topographical maps available not justifying a large scale. The area represented is about as great as that of England and represents about nine seasons' field work by two (sometimes three) men spread over the field season 1860-61 to 1868-69. In this memoir, King makes full use of the notes of Oldham and Foote, often quoting them *in extenso.* Apart from the underlying crystallines and a little alluvium, only two formations are represented on the map, namely two transition systems of old stratified rocks, designated *Karnuls* and *Kadapahs.* Each of these formations is divided into four sections designated groups or beds, to all of which names are given taken from suitable places. The Karnuls, the younger formation, are composed of shales, limestones and quartzites, of which the lowest division, the *Banaganpilly group,* with pebble beds, contains the well known diamondiferous horizon of Southern India, the diamonds being responsible for the older term *Diamond Sandstone* applied to both the Karnuls and the Kadapahs prior to their distinction by Oldham, King and Foote.

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[1] *Mem. Geol. Surv. Ind.*, VIII, pp. 1-319, 1872: it includes an Appendix (pp.293-313) by Foote on the northeastern end of the basin.

The gently dipping Karnuls rest with a great unconformity on the much disturbed Kadapah formation, composed principally of alternating quartzites, and slates, with some limestone, and with trappean sills. Whilst on its western margin, the Kadapahs rest at low angles on the older gneisses, the eastern margin of the basin is faulted. The thickness of the overlying Karnuls is only 1,200 feet, whilst that of the Kadapahs is 21,000 feet.

In attemtping to recognise the equivalents of these unfossiliferous strata in other parts of India, King is compelled to make use of lithological features. On this basis, he points out that the basal diamondiferous Banaganpilly group of the Karnuls may be the equivalent of the diamondiferous Rewah group of the Upper Vindhyans, the Kaimurs being then unrepresented in Madras. He also draws attention to the similarity of many of the Kadapah rocks, including jasper and contemporaneous traps, to specimens from Hacket's Gwaliors. And since the stratigraphical break between the Karnuls and the Kadapahs is much more thorough than that between the Upper and Lower divisions of the Vindhyans he finds it necessary (*loc. cit.*, p. 291).

> 'to look for representatives of the Kadapahs among the *Gwaliors* or other like formations which may be overlain as unconformably by the *Vindhyans*'.
>
> 'On this view the *Chey-air beds of the kadapahs* appear to answer best to the, *Gwaliors*'.

However, as King advocates, caution is necessary as the Cheyair beds are only one out of our groups of the Kadapah formation, all separated by unconformity and overlap.

The Southern Mahratta Country: After the completion of the memoir mentioned above, King went on furlough, from which he did not return until the autumn of 1870. Meanwhile, in the winter of 1869-70 Foote set out to examine the Transition strata cropping out from below the margin of the Deccan Trap working from the Raichur Doab in Hyderabad to Belgaum in the west in order to connect with Wilkinson's work in the Konkan and thus provide a second complete geological section across the Peninsula. He completed this work during the two following field seasons, 1870-71 and 1871-72. King, on his return from leave, surveyed to the north-east of Foote's ground as far as Gulbarga, studying *en route* the section of gneisses in the Tungabhadra river (An. Rep. for 1871, *Rec. Geol. Surv. Ind.*, V, p. 3). This work occupied the season 1870-71 and the beginning of the next field season, when King had to hurry to the Godavari area in which Blanford was unable to return owing to his diversion first to Sind and then to the Seistan Boundary Commission.

Meanwhile, during the years 1872-73 and 1873-74, Foote continued to expand the survey southwards into the Southern Mahratta country. It was now his turn to write an important memoir, almost a classic, namely

'The Geological Features of the South Mahratta Country and adjacent Districts' (*Mem. Geol. Surv. Ind.*, XII, pp. 1-268, 1876). The Geological map illustrating this memoir is on the scale of 16 miles to an inch, the area represented being about 16,000 square miles, of which a small portion at the north-east was done by King and the western end, in the Konkan, by Wilkminson. Of this, Foote surveyed about 10,000 square miles, between December, 1869, and May, 1874 (*loc. cit.*, p. 2).

In his account of the underlying *gneissic series* Foote recognises that this series is composed of two principal elements, of *granitoid* and *schistose* nature respectively, arranged in great bands that may be traced for many miles across the country with a general NNW-SSE strike. He describes the position and petrographic character of each band but does not demarcate their limits on his map. Amongst the schistose series, he recognises five varieties of schists, hornblendic, micaceous, chloritic, hematitic and talcose. In addition, associated with the schists are beds of crystalline limestone. Although the granitoid and schistose bands are not shown separately on Foote's map it is quite clear that we have in this memoir description of the north-western ends of the great bands of schists that he was later (1886) to separate from the gneissic complex as the *Dharwar* system.

The sub-metamorphic or Transition series of rocks overlying the gneissic series on the north are regarded as representing the Kadapah and Karnul series of the Kadapah basin, the more highly metamorphosed series to the west, termed the *Kaladgi series*[1] by Foote, being the equivalent of the Kadapahs, and the less metamorphosed series to the east, termed the *Bhima series*[2] by King, being the equivalent of the Karnuls. Foote points out (*loc. cit.*, p. 137) that petrographically, the Kaladgi series bears a strong resemblace to the Gwalior (or Bijawar) series of Central India, which King had already assumed as the probable equivalent of the Cheyair, group of the Kadapah series. But unlike the Kadapahs and Gwaliors the Kaladgi formation contains no contemporaneous traps.

In this memoir (*loc. cit.*, p. 200), Foote re-introduces Voysey's term *iron-clay* for the high level laterite: but, this term has since again fallen into disuse.

Godavari Valley: With the departure to Sind and Seistan of Blanford, the spearhead of the invasion by the Bombay Party from the Central Provinces down the Godavari Valley to the Madras Presidency, it fell to King to take up the survey of the Godavari Valley where Blanford had left off and to retrieve this belt for his party. This was in the field season of 1871-72: King continued to return to this belt as his principal field of work until 1879-80. The belt surveyed joined the ground

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1 *Mem. Geol. Surv. Ind.*, XII, pp. 17, 70, 1876

Op. cit., p. 139: and also T. Oldham *Rec. Geol. Surv. Ind.*, V, p. 3, 1872

surveyed by Hughes further north and included parts of the Nizam's Dominions, and of Bastar State in the Central Provinces, as well as the Godavari district of Madras. Papers on the progress of this work were published in the *Records* (V to VII) during Oldham's period, but the later part of the work was done under Medlicott, and the whole is described in Kings's memoir on 'The Geology of the Pranhita-Godavari Valley' published in 1881.

Nellore Carnatic: We must notice briefly King's Memoir on 'The Gneiss and Transition Rocks and other Formations of the Nellore portion of the Carnatic (*Mem. Geol. Surv. Ind.*, XVI, pp. 109-194), although it was not published until 1880, as it discusses work originally taken by Charles Oldham and King in 1861, whilst following out the transition rocks of the Cuddapah district. The publication of the work had been deferred to permit of the revisioning of portions of the district in which the relations of the Cuddapah rocks to the gneiss were complicated and obscure. But the reduced size of the Madras Party caused by the death of Charles Oldham had rendered this impracticable, so that King was asked to prepare this treatise based on the notes and observations recorded so many years before, a memoir that would most likely have been written by Oldham, as King notes. Concerning this tract all we need say here is that King divides the foliated rocks into schistose and massive gneisses, and that the schistose gneisses represent what was later to be called the Dharwar system, in which old copper workings existed, and in which the Nellore mica mines were subsequently to be opened[1].

Madras : We must notice briefly here a memoir[2] by Foote describing the geology of parts of the Madras and North Arcot districts on the Atlas Sheet immediately to the south of King's Nellore memoir. The principal and most important portion of this memoir is its detailed account of the Jurassic rocks of the Rajmahal series lying to the north-west and south-west of Madras. But little space is given to the metamorphic rocks, as these are similar to those described by King and Foote in Volume IV of the *Memoirs* describing the country immediately to the south Foote notes, however, that hornblendic varieties of gneiss predominate to the south-west of Madras, and he discusses briefly the rocks of St. Thomas Mount, Pallavaram, and the Seven Pagodas, that were to become the type exposures of Holland's charnockite series some twenty years later.

Wainad gold : In the field season of 1874-75, King was diverted from his Godavari Valley survey to examine the gold-bearing reefs of the Wainad[3]. The map accompanying his report records the distribution of five types of gneiss and of the auriferous quartz reefs.

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1 See *Mem. Geol. Surv. Ind.*, LXX, pp. 94-99, 1936 for fuller discussion of king's work on these gneisses.

2 *Mem. Geol. Surv. Ind.*, X, pp. 1-132, 1873; preceded by a shorter version in the *Rec. Geol. Surv. Ind.* III, pp. 11-17, 1870

3 'Gold-fields of the South-east Wynad', *Rec. Geol. Surv. Ind.*, VIII, pp. 29-45, 187

Pegu Province, Burma Theobald, who had gone abroad on furlough in April, 1867. returned in time to resume his survey of British Burma towards the end of 1868. This work he brought to an end in 1872-73, after which he was transferred to the North-West Provinces of India, where his experience of Tertiary rocks in Burma would prove valuable. The results of Theobald's many years of work in Burma were presented in his memoir 'On the Geology of Pegu' (*Mem. Geol. Surv. Ind.*, X, pp. 189-359, 1873) in which were laid securely the foundations of our knowledge of the geology of Burma from Cape Negrais up to Latitude 19°30′ North. When we recall Theobald's humble beginning probably without any geological training, it is pleasing that he was able so to benefit from his successive association with Williams, McClelland, Fleming and Blanford as to be able to produce this *chief d'oceuvre*, which has served as the basis of all subsequent work in this part of Burma. So well did Theobald do his work that the boundaries laid down by him on the map of 'Pegu Province' that accompanies his memoir are the boundaries that appear on the 1931 edition of the Geological Map of India as far north as the Latitude of Thayetmyo. Of the terms proposed by him to designate his Burmese formations, including the well known *Fossil-wood* group, *Pegu* group, *Negrais* group and *Axial* group, two still persist in the legend to the 1931 Geological Map. The ages ascribed to his groups were, of course, subject to the revision and his axial group, considered by him to be Triassic, is now regarded as composite and only in part of Triassic age. The Negrais group he regards as a band of metamorphism rather than a definite stratigraphical division (*loc. cit.*, p. 227). The numerous exposures of serpentine mapped by him, he regards as possibly not older than the earliest Tertiaries (*loc. cit.*, p. 226). The chapter on the economic geology of Pagu includes an account of the petroleum occurrences and of brine springs.

Trans-Frontier work During this period three geologists from India were engaged geological work beyond the Indian frontiers.

Aden: The first was Mallet, who, on his return from leave towards the end of 1870, was asked to break his journey and make an examination of the country round Aden and of the hills to the north, with a view to determining the possibility or otherwise of obtaining an artesian water supply. Mallet found that artesian conditions were nonexistent, but that abundant water could be obtained by pumping from alluvial beds to the north of Aden. He suggested making use of the prevailing wind as a source of the power required. His paper contains an interesting account of the Aden volcano[1].

Persia: In the winter of 1871-72, W. T. Blanford accompanied the Boundry Commission, under Sir F. Goldsmid, to Seistan to survey the boundary between Baluchistan and Persia. As naturalist to the expedition,

[1] 'On the Geological structure of the Country near Aden, with reference to the practicability of sinking Artesian Wells'. *Mem. Geol. Surv. Ind.*, VII, pp. 257-284 (1871).

Blanford produced Volume II of Goldsmid's 'Eastern Persia' dealing with Zoology and Geology, 576 pages, 1876, as well as an earlier 'Note on the Geological Formations seen along the coasts of Baluchistan and Persia from Karachi to the head of the Persian Gulf, and on some of the Gulf Islands' (*Rec. Geol. Surv. Ind.*, V, pp. 41-45, 1872). It is in this latter note that Blanford proposes the name *Makran group* for the younger marine Tertiary beds along the Makran coast of Baluchistan. He also calls the underlying beds of Hormuz Island the *Hormuz salt formation*, the age of which he was unable to suggest[1].

The third trans-frontier deputation, that of Stoliczka in 1873-74, with the Yarkand Mission, resulting in his untimely death has already been noticed.

Economic Geology From the description of the progress of geological survey operations given in the preceding pages the reader may have gained the impression that the Geological Survey of India was being conducted almost solely as a branch of scientific research. This, of course, is not so. The main purpose of the maintenance of a Geological Survey department by any country is the promotion of its economic welfare in so far as this is related to mineral resources, engineering problems, water supplies and agriculture. None of these economic aspects of geology can, however, be evaluated in its true perspective without a knowledge of the foundations of the geology of the country, so that the foremost object of any national geological survey must be the systematic production of geological maps. As will be seen from a perusal of the correspondence between Thomas Oldham, the Government of India, and the court of Directors of the East India Company, quoted in the Appendices to Chapter, IV, Oldham was very insistent on the necessity for the systematic progress of geological mapping, so that economic problems should fall into their appropriate places during the course of the investigation. However, he recognised that the original reason for the appointment of a Geological Surveyor by the East India Company was the study of the coal resources (and other minerals) of India. Consequently, a large proportion of the systematic work done during Oldham's regime of 25 years was directed to the study of coalfields; and by the time he retired, surveys had been made and descriptions published of a large proportion of these coalfields, partly in the *Memoirs*, but to a smaller extent in the *Records*.

In addition, every Memoir had its chapter on the economic geology of the area described; and in this way, not only were the coal resources of the country described, but also the iron-ores, the limestones and building stones, the salt deposits of the Salt Range, the petroleum springs of Assam, the Punjab, and Burma, and numerous minor occurrences of a great variety of other minerals.

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1 Shown later by Pilgrim to be Jurassic, with a possibility that the basal Salt is Triassic. See *Mem. Geol. Surv. Ind.*, LI, p. 85.

In addition to this steady sweeping of minerals of economic value into the net of systematic description, special visits were often made at the request of Governments, Central and Provincial, to examine mineral occurrences the importance of which, apparent or real, had come to public notice.

There are several small papers in the first nine volumes of the *Records* dealing with such mineral occurrences and enquiries. To only a few of these need we make reference. Of two successive papers on the copper deposits of Dhalbhum and Singhbhum, the first is a translation (by Ball) of one in German by Emil Stoeh descriptive of mining on the Dhalbhum lodes between 1855 and 1859, and the second is a later report by Valentine Ball (*Rec. Geol. Surv. Ind.*, III, pp. 86 and 94, respectively, 1870), latter paper containing a map that is a precursor to that in his later *memoir* (XVIII) of 1881.

A third paper deserving notice is Foote's 'The Auriferous rocks of the Dambal Hills, Dharwar District' (*Rec. Geol. Surv. Ind.*, VII, pp. 113-142, 1874) in which he traces the stream-gold, so long known to occur in this neighbourhood, to at least one auriferous reef. We have already noticed King's paper on gold in the Wainad.

The preparation of a set of specimens from the Salt Range for the Vienna Exhibition of 1873 led to the discovery by Dr. Warth of potash salts consisting of sylvine and kieserite, which were exhibited in Vienna (see *Rec. Geol. Surv. Ind.*, VII, p. 64, 1874).

Iron-smelting Finally, we must refer to the question of iron-smelting in India. Iron ores have long been known to occur in India, and smelting in primitive shaft furnaces has been practised from time immemorial, with the production of the pure iron known as wootz, of which the iron pillar at Delhi is a famous example. From the commencement of official geological investigation in India, the most important problem after the investigation of coal has been the possibility of producing in the country the iron needed for the construction of railways. Williams discussed the possibilities of iron manufacture in his second report (1852). Iron works were established from 1857 to 1860 in Kumaon using local iron-ores and limestone and wood as fuel. Dr. Oldham in 1860 (Paper No. 26 in La Touch's Bibliography) reported to Government on the management of the Dechauri works in Kumaon, declaring it to be both extravagant and incompetent; but the enterprise struggled on till 1864 under private management. In 1872, Mr. Hilary Bauerman, a contemporary of H. F. Blanford at the the Royal School of Mines, and an authority on the metallurgy of iron, was sent to India by the Secretary of State with a view to giving a definite opinion on the feasibility of establishing iron works in India (An. Rep. for 1872, *Rec. Geol. Surv. Ind* VI, p. 2). Valentine Ball was deputed to accompany him. Bauerman's report on the prospects of resuscitating the manufacture of iron in Kumaon was unfavourable, and as this view was not acceptable to the local authorities, T.W.H. Hughes was deputed to make a further report. Hughes examined the deposits of iron-ore and limestone and found them adequate, and also

the water-supply; but in the absence of local coal only wood fuel could be used, with the usual limitation on the size of the industry if forests were not to be denuded (*Rec. Geol. Surv. Ind.*, VII, pp. 15-20, 1874)[1].

Bauerman, as a result of his visit to India, produced a preliminary 'Report on the Iron Ores of India'[2] dated 1874, and apparently of trivial dimensions. Medlicott's views on Bauerman's visit are contained in his Annual Report as Officiating Superintendent (*Rec. Geol. Surv. Ind.*, VII, p. 6, 1874), from which the following may be quoted:

> 'Even if Mr. Bauerman's deputation to India had not so directly touched upon the work of the Geological Survey, it would call for notice here. He is the latest and no doubt the most competent of a series of experts sent out from England to report on the practicability of iron manufacture in India on European methods. His preliminary report containing the general result of his observations has been published; but the question seems to stand pretty much as before. Mr. Bauerman has simply restated the case in a more intelligible form than some of his predecessor, but no more so that it has all along been expressed by the Geological Survey that, under existing circumstances, the Raniganj coal-field is the most promising place for a trial, the principal defect there being the flux; and the Survey has been called upon to furnish further data. The only good to be expected from Mr. Bauerman's visit is, to establish the opinion that actual trial must be the next stage of the enquiry'.

Hughes followed up his work in Kumaon by two notes on the raw materials for iron smelting in the Raniganj coalfield (*Rec. Geol. Surv. Ind.*, VII, pp. 20-30 and 122-124, 1874).

He gives an account of the raw materials available for use at Raniganj, points out that the weak point about Indian coal is its high ash content; he conducts experiments (assays) at the Mint in Calcutta, using the local products of Raniganj, iron-ore, kankar, and charcoal or coke, and he obtains buttons of iron. He is, evidently, favourably impressed with the possibilities of producing pig-iron in India and would chose a site on the Raniganj coalfield near the Barakar river, as being convenient for the supply of all the raw materials needed, including furnace-building material[3].

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1 Nevertheless, Government did again embrak on the manufacture of iron in Kumaon, from 1877 to 1879, and Pig-iron was produced. For a good summary of these efforts in Kumaon. See V. Ball, 'The Manual of Geology of India', Vol. III, Economic Geology, pp. 406-411, 1881.

2 See La Touche's Bibliography

3 In 1874, the Bengal Iron Company was formed, works were erected at Kulti near, Barakar, and 12,700 tons of pig iron were produced from the commencement of work until the stoppage in 1879. An account of this venture, with analyses of raw materials and of products, is given by Ball in the Manual of the Geology of India, Vol III, pp. 368-373. He attributes 'this disaster' principally 'to the fatal and initial error of starting with insufficient capital, which only amounted to £100,000'.

This enterprise was, of course, the precursor of the Bengal Iron and Steel Company of 1889 and the Bengal Iron Company of 1919, the latter being ultimately merged with the Indian Iron and Steel Company of 1918, now a large and successful producer of both pig-iron and steel. See *Rec. Geol. Surv. Ind.*, XXXIX, p.102 (1910); and LXX, pp. 126, 130 (1936).

Earthquakes That Northern India, particularly the mountain belt fringing the Indo-Gangetic alluvial plain from Baluchistan *via* the Himalaya to Assam—and also much of Burma, is liable to the incidence of destructive earthquakes at fairly frequent intervals is well known. Since the cause is geological, it is the duty of the Geological Survey of India, when a serious earthquake occurs in India, to investigate the damage in the field, and from the evidence collected to draw conclusions as to the source and cause of the earthquake; and also to advise on the building precautions that are suitable for such seismically unstable tracts. It has been a cause of surprise to the writer, in viewing 25 years of progress under Thomas Oldham, that no serious earthquake occured to affect the course of the Department's investigations until the Cachar Earthquake of the 10th January, 1869. This was an earthquake of the first magnitude and was investigated in the field by Thomas Oldham himself (see *Rec. Geol. Surv. Ind.*, III, p. 1, 1870); and a brief notice of the results of these investigations was given to the Asiatic Society of Bengal in March of the same year (see *Proc. A.S.B.*, p. 113, 1869). He also wrote a scholarly memoir on this earthquake, which was published after his death, his son, R. D. Oldham, who joined the Department in 1879, acting as editor thereto (*Mem. Geol. Surv. Ind.*, XIX, pp. 1-98, 1882). This earthquake led Thomas Oldham to discover (*Rec. Geol. Surv. Ind.*, III, p. 2):

> 'now little of any accurate record existed in this country regarding the earthquake shocks to which many parts of it are frequently subject. And I have, therefore, given some time to the preparation of as perfect a catalogue of Indian earthquakes as I had means of obtaining'.

The catalogue so prepared, with the title 'A Catalogue of India Earthquakes from the earliest time to the end of A. D. 1869', was also published posthumously in the same volume of *Memoir* (XIX, pp. 163-215). In this catalogue, no less than 91 earthquakes are recorded as having occurred in India, with eight in Burma, during Thomas Oldham's time, prior to the Cachar earthquake of January, 1869. Some of these distant cnes, in Baluchistan, North-Western India, and Nepal (Gwadar, Baluchistan, 19.4.51: Murree Hills, 24.1.52: Khatmandu, Nepal, 23.5.66.), in tracts outside the limits of India as it then stood, or in country to which the work of the Geological Survey of India had not then been extended. There was also a very serious earthquake at Prome and Thaymatmayo in Burma on the 24th August, 1858, but Geological Survey work had not then been extended to Burma. Of the 91 shocks in India, no less than 28 were recorded from Southern India, either in or close to my charnockitic region (*Mem. Geol. Surv. Ind.*, LXXII, p. 49), and shocks were experienced in this region by King and Foote in the Salem district in 1860 and 1861 (*Mem. Geol. Surv. Ind.*, IV, p. 365), and in the Kistna and Nellore districts by Foote (113, 1867; *Mem. Geol. Surv. Ind.*, XVI, p. 38). We must assume that Oldham experienced some of the earthquake shocks that were felt in Calcutta and Assam prior to 1869 and that he had already commenced the preparation of his list of Indian earthquakes when the great earthquake of Cachar of 1869 caused him to take the field himself. He then initiated the long line of careful investigations of Indian

and Burmese earthquakes that has continued ever since, and in which so many of the officers of the Geological Survey of India have participated, with the production of exhaustive and scholarly memoir such as those (to mention only works relating to the most destructive earthquakes) by R. D. Oldham[1], Middlemiss[2], J. Coggin Brown[3], W. D. West[4] and the authors of the memoir on the Bihar-Nepal earthquake of the 15th January, 1934[5].

The succession and frequency of earthquakes in India has been such that almost every Director of the Geological Survey of India has found it necessary at one time or another to detach geologists from their regular work to investigate urgently and report upon earthquake damage[6].

This frequency has led to the development of a technique of earthquake investigation, including the issue by post to all affected places, immediately on the receipt of news of an important earthquake of a standard form to enable observers to record their experiences and impressions whilst these are still vivid. The data, thus, secured are collated at headquarters whilst the field officers are at work at the loci of greatest destruction. The Department does not, however, maintain seismographs, which instead are kept at certain principal stations of the Meteorological Department and at the headquarters of Geodetic section of the Survey of India, where there are available staff constantly engaged in recording physical observations for other purposes. Unfortunately, there are not enough seismograph stations in India—for a country so afflicted with destructive earthquake shocks. All the information thus obtained by geologists in the field, by observatories, and from circular letters of enquiry, is collated in the preparation of the memoirs referred to above. It is doubtful if there can be any other geological survey department in the world that has produced so long a record of important *Memoirs* and *Records* on earthquakes.

The important part that earthquakes have played in the work of the Geological Survey of India is, perhaps, illustrated by the fact that it was Mr. R. D. Oldham who first distinguished[7] the three distinct forms of wave-motion represented in the seismograph records of earthquakes, namely the two preliminary tremors representing bodily waves (P and S), compressional and distortional, that travel direct through the earth, and the

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1 Assam: 12.6.1897 : *Mem. Geol. Surv. Ind.*, XXIX
2 Kangra : 4.4.1905 : *Mem. Geol. Surv. Ind.*, XXXVIII
3 Burma : May, 1912 : *Mem. Geol. Surv. Ind.*, XLII
-do- , 1930 to 1932 : *Mem. Geol. Surv. Ind.*, LXII (with P. Leicester)
4 Quetta : 31.5.1935 : *Rec. Geol. Surv. Ind.*, LXIX
5 D. N. Wadia, J.A. Dunn, J.B.Auden, and A.M.N. Ghosh: *Mem. Geol. Surv. Ind.*,Vol.78
6 During his period of charge of the Geological Survey of India, the writer had to send, officers to investigate no less than eight serious earthquakes, namely those of Pegu and Pyu in Burma (1930), Dhubri in Assam (1930), Sharigh and Mach in Baluchistan (1931), Kamaing in Burma (1931), North Bihar and Nepal (1934) and Quetta (1935), the death roll at the last two being estimated at over 10,000 and over 25,000 respectively.
7 *Phil. Trans. Roy. Soc.* Ser, A. Vol. CXCIV, pp. 135-74 (1900)

main tremors due to surface waves. From a study of the records of these preliminary tremors, Oldham was able to draw conclusions of fundamental importance concerning the constitution of the interior of the earth[1] and especially to distinguish between a dense core and a lighter shell, and to determining the approximate diameter of this heavy core (a radius about four-tenths that of the earth).

Thermal Springs Some time before he retired, Thomas Oldham prepared a list or catalogue of the thermal springs of India, the criterion for inclusion in this list being the temperature of the water, which had to be above the mean temperature at the locality where the spring occurred. Copies of this list were printed and circulated to several local governments and authorities before Oldham's retirement, with the resultant receipt of additional information. The revised list was edited by his son, R. D. Oldham, and is included in the same volume of the *Memoir* as the catalogue of earthquakes (XIX, pp. 99-161). Thomas Oldham remarks that:

> 'The special point of view from which these thermal springs became, on the present occasion, interesting being their connection with earthquake phenomena and volcanic or quasi-volcanic phenomena'.

The number of springs listed is 301.

Publications During the years 1868 to 1876, the publication of the *Memoirs* of the Geological Survey of India was completed to the end of Volume XII, whilst volumes XIII and XIV, and parts of volumes XV to XIX, published between 1877 and 1883, all represent work done during Oldham's time, and have been noticed in the accounts of researches given in the preceding pages.

Turning to the *Palaeontologia Indica,* we find that by 1873, Stoliczka had completed the description of the Cretaceous Fauna of Southern India begun by H. F. Blanford, the total of this stupendous work amounting to 1455 pages and 201 plates, all but 40 pages of the text being from Stoliczka's pen. Waagen's account of the Cephalopoda in 'The Jurassic Fauna of Kutch' was published in 1873-75, and Feistmantel's 'Jurassic (Oolitic) Flora of Kach' in 1876.

Volumes I to VIII and the first part of volume IX of the *Records* were published during Thomas Oldham's period, whilst the remainder of volume IX, and much of volume X record work was done during his time. Many of the papers in the *Records* are, of course, preliminary to fuller treatment in the *Memoirs,* but some papers have been thought worthy of separate notice above. We must mention specially here Feistmantel's 'Notes on the Age of Some Fossil Floras of India' which appeared in XIX parts in Volumes IX and X of the *Records* representing partly work done during Oldham's time, but of which the first parts (I and II) did not appear until May, 1876

[1] *Q.J.G.S.*, LXII, pp. 456-475 (1906).

in Part 2 of Volume IX, immediately following Oldham's retirement in April. We must also mention a series of papers inaugurated by Oldham in the form of Sketches of the Geology of various provinces and areas, apparently first written as contributions to Provincial Gazetters (An. Rep. for 1874, *Rec. Geol. Surv. Ind.*, VIII, p. 9). The following is the list of such articles:

1871,	T. Oldham,	Central Provinces,	*Rec. Geol. Surv. Ind.*,	IV, p. 69
1872,	W. T. Blanford,	Orissa	-do-	V, p. 56
1872,	-do-	Bombay	-do-	V, p. 82
1873,	H. B. Medlicott,	North-west Provinces	-do-	VI, p. 9
1873,	A. B. Wynne,	Part of the Punjab	-do-	VI, p. 59
1875,	H. B. Medlicott,	Gwalior	-do-	VIII, p. 55

Blanford's 'Geology of Sind' *Rec. Geol. Surv. Ind.*, IX, p. 8 (1876), describing original surveys, does not belong to the above series.

It is, perhaps, desirable to notice the general plan adopted in volumes of the *Memoirs* descriptive of the geology of large tracts of country. The order adopted is not invariable. But every memoir contains, usually at the beginning, a summary of the writing of previous observers, many of them amateurs, so that the *Memoirs* of the Geological Survey can be treated as complete guides and sources of reference to the geology of the tracts described. Next, usually, comes a description of the physical aspects of the terrane, including notice of rainfall and vegetation and sometimes of the fauna and the people. The rock formations are then described in order starting from the oldest, and after this the geology of the area is described in detail, section by section, followed often by sections on the structural features, and on the correlation with similar formations in other parts of India. Finally, there is a chapter at or near the end of the *Economic Geology* of the tract described.

First official Geological Map of India, 1877

An important task that Dr. Thomas Oldham had hoped to undertake before he retired was the preparation of a Manual of the geology of India, in order to present to the public an account of the results of the labours of the Geological Survey of India as far as this had then extended. Unfortunately, failing health and the pressure of other duties, prevented him from even commencing the task which fell to his successor, H. B. Medlicott, in collaboration with W. T. Blanford. But the Geological Map of India that illustrates the Manual (published in 1879) was published before the Manual itself, namely in 1877, a year after T. Oldham's retirement and it is clear from the preface of the Manual (p. vi) that this geological map had been partially compiled before Oldham's retirement. In any case, the geology represented thereon summarises the results of the surveys made during the first 25 years of the Geological Survey of India under the superintendence of its founder, Thomas Oldham. This map is entitled 'Preliminary Sketch of the Geology of India by the officers of the Geological Survey of India (first issue) 1877', and is on the scale of

64 miles to an inch. Although, it is only a preliminary sketch, yet it must be regarded as a remarkable monument to Thomas Oldham and his team of able geologists, who, on broad lines, soundly laid the foundations of our knowledge of the geology of India. Comparison with the later geological maps of India, such as the Second Edition, on the scale of 96 miles to an inch, published in 1891 with the Second Edition of the Manual (1893), and the Fifth Edition on the scale of 32 miles to an inch published separately in 1931, shows that all later work has been fitted confortably into the 1877 framework. Much additional information has, of course, been added, such as for Burma, the Central Provinces, Rajputana, and Baluchistan, and for such trans-frontier countries as Afghanistan, Tibet and Western China ; and much detailed work has been done within the 1877 framework; and the Dharwars and other formations have been separated from the general Archaean complex that occupies so large a proportion of the Indian Peninsula. But, essentially, our knowledge of the general boundaries, and the nomenclature of our geological formations, is based on the first 25 years work of the Geological Survey of India.

Greenough's Geological Map of India, 1854

This 1877 map cannot, however, be hailed as the first general geological map of India. For, G. B. Greenough in 1854, at the Liverpool meeting of the British Association, presented a large geological map of this country entitled 'General Sketch of the Physical and Geological Features of British India', together with a paper 'on the Geology of India'.[1] This map which is beautifully engraved on stone by A. Petermann, 9, Charing Cross, London, is a compilation bearing no date or scale, but the latter is approximately 1:2,000,000 or 32 miles to an inch. A copy of the map was transmitted by the Court of Directors of the East India Company in London, to the Government of Bengal and by the latter to the Asiatic Society of Bengal for an expression of the opinion of the Society on the merits of the map. The Society appointed a special Committee to consider this. The Committee's Report[2] was presented in August, 1856, and was signed by Thomas Oldham and five others, including Major Thuillier of the Survey of India (? Deputy Surveyor-General) and the report was a very adverse one. Apparently, Greenough had spent 20 years on this compilation and has used quite out-of-date topography, too inaccurate for the basis of a careful geological map. Also, he did not state his sources of information. The Committee proposed that the map should be allowed to remain in its present condition 'to form a memorial of our geological knowledge at the time of its publication': and they deprecated any attempt to bring Greenough's map up-to-date (he had died in 1855). To the Committee report is added a Memorandum containing 53 corrections, geological and topographical, that would be necessary.

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1 *Rep. Brit. Assoc.*, XXIV, Transactions of the Sections, pp.83-88 (1855). See also *Q.J.G.S.*, XI, p. LXXXVII (1855).

2 *J.A.S.B.*, XXV, pp. 419-426 (1856)

Reading between the lines concerning the incidents of this unfortunate publication, it seems permissible to deduce that the Court of Directors, not having received geological maps from their own Geological Surveyor, Thomas Oldham, were contemplating using Greencugh's map as the basis for a Geological Map of India[1]. It is curious that the Government of Bengal asked for the opinion of the Asiatic Society of Bengal on this map and apparently by-passed Oldham cfficially. The incident can, I think, be understood if it is considered in conjunction with the animated correspondence in 1855-56 between Oldham, the Government of India and the Court of Directors when the terms of Oldham's appointment for a second term of service were being discussed (see Çhapter V and Appendices to Chapter IV for this correspondence.

It seems a pity that Greenough should have ever published a geological map about a country he had not visited. For, as has already been emphasised, geology is done by walking[2]

The Curator and Chemist

During this period, 1867-76, Tween remained Curator of the Geological Museum, combining this duty with that of chemist to the department[3]. In September, 1876, he followed Thomas Oldham into retirement, on account of failing health, after a service of 17 years during the greater part of which he had carried out the chemical duties of the department. His analyses are to be found scattered through the reports of other officers, mainly in the sections devoted to the minerals of economic value, especially coal and iron-ores. Four papers under his name are listed by La Touche, of which the most important is his 'Analyses of Raniganj Coals' (*Rec. Geol. Surv., Ind.*, X, *pp*. 155-158, 1877). This paper contains a two page table of analyses of 31 bulk samples made during 1870 to 1873, both proximate and ultimate, with complete analyses of the ash, and with specific gravity determinations, and also a note on the samples by Hughes. Although Tween was Curator for so many years, he

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[1] Indeed, it is possible that the Court of Directors purposely encouraged Greenough in his enterprise, for the map carries an ornamental inscription in the following words: 'The Author desires to express his respectfull thanks to the Hon. Directors of the East India Company, and especially to Lieut. Col. Sykes, as also to the respective Officers of the Library department for the facilities which have been afforded him in consulting their Geographical and Geological Archives'.

[2] It is curious that the Geological Society in London of which Greenough was the first President, should have no copy of his geological map of India. But two copies have been located in London; one with the Geological Survey of Great Britain, and the other in the former India Office Library, now in the Commonwealth Relations Office.

[3] There was also an Assistant Curator, named T.H.Turner, who is recorded as Chief Draftsman and Clerk in 1867 and as becoming Assistant Curator in April, 1869, which post he held until his death on the 9th June, 1878: thereafter, this post was dispensed with, as the two apprentices, Kishen Singh and Hira Lal were by then able to do the work (see *Rec. Geol. Surv. Ind.*, XIII, p. 10)

was not the first to hold this post; for, H.F. Blanford was Curator before Tween arrived in India in 1859[1].

Whilst Tween was on leave in 1868, Mr. Geoffrey Nevill acted as Temporary Curator, and was engaged in arranging, preparing, and cataloguing the Klipstein collections of fossils (An. Rep. for 1868, *Rec. Geol. Surv. Ind.*, II, p.33)[2].

Other work in the Geological Museum needing notice is the arrangement and cataloguing of the mineral collections by Mallet during the recess periods of 1871 to 1873. Mallet also acted as Curator for 3 months in 1871 during the absence of Tween on privilege leave (An. Rep. for 1871, *Rec. Geol. Surv. Ind.*, V, pp. 5-7: aslo VI, p.7, and VIII, p. 11).

The Geological Museum

We have already seen that in 1856, the Museum of Economic Geology, hitherto housed in the premises of the Asiatic Society of Bengal at No. 1 Park Street, was transferred to the new premises of the Geological Survey of India at 1, Hasting Street. When this happened, it was proposed that at the same time the society should deposit there on loan its own collection of fossils and other geological specimens. Opinions were divided in the Council of the Society on the advisability of acceptingt this offer of Government; the matter was decided at the Annual General Meeting of the Society in January, 1857 by an adverse vote (15 against to 14 votes for). An important factor in producing this vote was the fear[3]

> 'that the dissociation of a part of the Museum, and that the least expensive by highly valuable, would prove injurious to the interests of the Society, if not to endanger its very existence, and at the same time postpone to an indefinite period the great object which the Society had cherished since 1837 of seeing a national museum worthy of the metropolis of British India established here'.

The Indian Museum

Later in the year (6th May, 1857), the Society authorised the Council (*loc. cit.*, p.44) 'to enter into a communication with the Government on the subject of the foundation at Calcutta of an Imperial Museum, to which the whole of the Society's Collections, except the Library may be transferred'.

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1 'Centenary Review of the Asiatic Society of Bengal from 1784 to 1883', p. 43 (1885)

2 See Obituary notice of Tween, *Rec. Geol. Surv. Ind.*, XXXVIII, p. 10, 1908, also chapter V.)

3 Nevill's permanent post, after the foundation of the Indian Museum as a separate institution in 1866 (see later), was Assistant Secretary and Librarian thereto. He acted as Assistant Curator to the Indian Museum in 1870 and 1881 and was First Assistant to the Superintendent, Indian Museum from 1879 to 1884. His special study was molluscs (see 'The Indian Museum: 1814-1914').

The onset of the Mutiny, immediately after, caused a postponement of action, but the proposal was revived in 1858 (Letter dated October 8th, 1858). The Government of India, though recognising its duty to establish in the Metropolis an Imperial Museum, declined to entertain the proposal on financial grounds. But at the same time, the Government renewed its offer to relieve the Society by taking over the geological and palaeontological collections. The members of the society were, however, insistent and memorialised the Secretary of State for India in a letter dated September 15th, 1859[1].

These efforts were successful, and in May, 1862 the Government of India announced that in their opinion the time had arrived when the foundation of a public museum in Calcutta could be taken into consideration and then gave a sketch of the terms on which the Society's collection could be transferred to it. The resultant negotiation lasted until the middle of 1865; and it was provided that in the Museum to be built the Society should be provided with suitable accommodation of which it should have the exclusive possession, besides retaining its own house in Park Street and that it should also have the right of nominating from its own members one third of the members of the Board of Trustees to be appointed to administer the Museum. Legislative sanction was given to the conditions in the Indian Museum Act (No. XVII) of 1866. But the time occupied in building the new museum was so long that by the time it was finished, collections had so increased that the officers in charge of the Museum and the Board of Trustees were of opinion that the whole of the accommodation would ultimately be required for Museum purposes; whilst the Asiatic Society felt that their position as an independent body would be injured by its office being huddled in the corner of a house occupied by two such large establishments as the Geological Survey and the Natural History Museum. The Government, thereon, referred, the matter to a Committee consisting of 'one of the most sagacious administrators and one of the acutest scientists in the country, Sir Ashley Eden and Dr. Thomas Oldham'. Upon their joint recommendation, the Government of India paid to the Asiatic Society the sum of Rs. 1,50,000 as compensation for its claim to accommodation in the Museum building (Proceedings, July, 1876). This arrangement has proved highly beneficial both to the society and to the Museum.

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[1] There is a copy of this correspondence in the Library of the Geological Society of London (1954). The title is 'Correspondence between the Government of India and the Asiatic Society of Bengal relative to the establishment of a Public Museum in Calcutta, Baptist Mission Press, Calcutta, 1859.

On this question reference may also be made to the Centenary Review of the Asiatic Society of Bengal, already cited: and to the Centenary Volume of the Indian Museum entitled 'The Indian Museum: 1814-1914', Baptist Mission Press, Calcutta 1914.

It was not till 1875 that the Museum building became ready for occupation, when the geological collections belonging to the Geological Survey were moved to the new building[1].

The old quarters in Hastings Street were vacated on the 30th September in the same year and on the 1st January, 1877, the new Geological galleries were thrown open to the public[2].

The geological collections of the Asiatic Society had been made over to the custody of the Geological Survey in 1866, but had remained in the premises of the Asiatic Society; and it was not until 1876 that they were amalgamated with the collections of the Geological Survey and incorporated in the Geological Museum. The specimens continued, however, to bear distinguishing numbers that recorded their A.S.B. ancestry. Although the minerals thus transferred were of little value, the fossils included a valuable, though small, collection of Siwalik vertebrates.

The task of arranging and labelling the combined collections in their new home was an arduous piece of work in which Mallet, Lydekker, and Feistmantel took the largest share. Mallet was, of course, continuing the work on the mineral collections commenced in Hastings street. His work in the Mineral Gallery was so well done that his arrangement of the mineral collection persists to this day. It preserves one peculiar feature, namely that the specimens are arranged in the cases from right to left as one reads a document in Urdu or Persian.

This new Indian Museum building is, of course, the fine building in Chowringhee Road, as it stood before the extensions brought to completion in 1912[1].

The Original plans[2] were drawn up in the 'sixties' by W. L. Granville, who was also responsible for several other buildings still prominent in Calcutta, notably the General post Office and the High Court. They were prepared in consultation with the late Dr. Thomas Oldham.

It is quite clear that Dr. Thomas Oldham was one of the moving spirits in promoting the establishment of the Indian Museum, not only in respect of its planning, but also in the administrative arrangements. In this, he was available in two capacities: one as Superintendent of the Geological Survey of India and Director of the Geological Museum; the

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1 The transfer of specimens may have begun in 1874. See *Rec. Geol. Surv. Ind.*, VII, p.7

2 The Archaeological gallery and the bird and mammal galleries were opened to the public in 1878.

See Plate facing page 124, 'The Indian Museum: 1814-1914' for a view of the original Museum; and Plate facing page 8 for the extended Museum as it is at present.

second in his position in the Asiatic Society, of which he was President in 1868, 1869, 1872, 1873 and 1876, and Vice-President in 1862, 1870, 1871 and 1875. Moreover, H. F. Blanford was General Secretary from 1863 to 1868, and Dr. F. Stoliczka was Natural History Secretary from 1869 and 1873.

Although, Oldham did not have the satisfaction of seeing the geological galleries in the new building opened to the public, yet he was able to supervise the transference of the Survey offices and collections to the new premises; and we must picture him as having had the pleasure of writing notes and reports in a new office in the building in the planning of which he had played so large a part.

It must be emphasised here that although the Geological Museum and the offices of the Geological Survey were housed in the new Indian Museum, it is quite clear from the Indian Museum Acts (XVII of 1866, and XXII of 1876) that, unlike the zoological and archaeological collections, the geological collections did not come under the control of the Trustees of the Museum, but instead remained the property of the Geological Survey and under the control of the Superintendent of the Geological Survey of India. The connection between the Geological Museum and the Trustees lay in the provision in the Museum Acts that the Superintendent of the Geological Survey was *ex officio* a Trustee.

Geologists as Naturalists

In the early days, officers of the Geological Survey, by their extensive travels in tracts where other naturalists had often not then penetrated, had unrivalled opportunities of making natural history collections, apart from those of a geological or mineralogical nature. Some of them took great advantage of these opportunities and often presented their collections first to the Asiatic Society of Bengal and later to the Zoological section of the Indian Museum. Three geologists stand out prominent amongst those who enriched the zoological collections, namely W. T. Blanford, Ferdinand Stoliczka, and William Theobald[2]. Blanford made extensive collections of mammals and birds on his expeditions to Abyssinia and Persia, and to various parts of India; the majority of his types of mammals are still preserved in the Indian Museum, whilst the mollusca studied by him during his retirement are in the British Museum. Stoliczka described a long series of Indian and Malayan molluscs, frogs and reptiles, and many of his specimens are also in the Indian Museum. Theobald worked on reptiles and molluscs and his collections are still of great value. Of other geologists one must mention Valentine Ball whose hobby appears to have been the study of birds[3].

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[1] *Op. Cit.*, p. 124.

[2] 'The Indian Museum : 1814-1914', pp. 69-71,74,79.

[3] 'Jungle Life In India', p. 703.

As is well known, after his retirement from India, Blanford inaugurated the official 'Fauna of British India' series, acting as editor thereof, himself writing the volume on mammals and two of the four volumes on birds, as well as commencing the first volume on mollusca, which on his death, was completed by Colonel Godwin Austen. Lydekker also took a special interest in mammals, which was suitable for a vertebrate palaeontologist; after retirement he wrote several works thereon, as well as editing the Royal Natural History, in six volumes.

Geologists in India appear to have paid much more attention to the fauna than to the flora; Ball seems to have been more interested in plants than anyone else, judging from his 'Jungle Life in India'. In many of the departmental memoirs also, there are references to the principal or common trees in the tracts described.

Vienna International Exhibition

In 1873, an International Exhibition was held in Vienna. It had been decided to send there a good series of specimens illustrative of the mineral wealth of India. This entailed a large amount of work on all the officers of the Survey, and for the most part it was necessary to collect new and fresh specimens for Vienna. References to this will befound here and there in the *Memoirs* of the Survey describing work done at this time. In addition, it was decided to send some of our unique and valuable collection of fossils (An. Rep. for 1872 *Rec. Geol. Surv. Ind.*, VI, p. 7). It had been arranged that Dr. Stoliczka should attend the gathering at Vienna as the exhibitor of these latter specimens, but instead, he eagerly gave this up in order to accompany the Yarkand Mission as naturalist. Thomas Oldham, however, was himself on sick leave in Europe and accordingly went to Vienna to put our collections in order, being helped in this by King, also on leave (An. rep. for 1873, *Rec. Geol. Surv. Ind.*, VII, pp. 1, 5, 7,11).

The policy thus begun was continued years later with the despatch of a collection to the Paris Exhibition of 1900, in charge of the then Asistant Curator, T. R. Blyth. During the present century the department has sent collections to Nagpur (1908), to Lahore (1909) and to the British Empire Exhibition In London (1924), in all cases arranged by officers of the Department. In the provision of material for such exhibitions, we have usually been helped by mining and other commercial enterprises with the supply of specimens of their materials and work. Of the collections sent to such exhibition, only those specimens have been brought back to Calcutta that are indispensible for our own collections. The remainder have been presented to suitable museums, foreign or local.

Personal Reminiscences

To many, the interest of a history is enhanced if the his-torian has known some of the characters. It will therefore, perhaps, be agreeable to the reader if I recall meetings such four of the officers of the Geological Survey of India who were members of the service during the initial period under Thomas Oldham. These four are

Dr. W. T. Blanford (1855), R. Bruce Foote (1858), F. R. Mallet (1859), and Richard Lydekker (1874), the dates given being those of joining the services.

My first meeting with Blanford—an interview in 1902 for appointment to the service—has already been recorded (Chapter IV). After my appointment, Dr. J. M. Maclaren (just appointed as Mining Specialist) and I were invited by Mrs. Blanford to a dinner party at their house in Bedford Gardens, Campden Hill. Bruce Foote was also present, and my memory of him is his prediction that because I was fair (of complexion) I should be badly bitten by mosquitoes in India. Fortunately, the prediction did not come true, partly no doubt because of the avoiding action taken by me, and possible partly because I soon became darker under the Indian sun . Bruce Foote, who had retired to Yercaud in the Shevaroy Hills in Southern India, I met again when he visited Calcutta at some time before his death in 1912. With his smoking cap, he seemed like patriarch of the past.

By the time of my first leave from India in 1908, Blanford had died (1905) but I made a point of calling upon Mallet, who lived at Ealing near London. I was received with friendly hospitality by the family (Mr. and Mrs. Mallet and daughter) and an afternoon visit was prolonged into the evening with refreshment by Marsala wine. Mallet had a chemical laboratory in his home and still amused himself with chemical analysis.[1]

Lydekker I met before going to India, at a dinner of the Geological Club, at the Pall Mall Restaurant in London, as a guest of Professor Judd with T. H. Holland and Lt. Col. Alcock, I. M. S. Superintendent of the Indian Museum, both on leave from India. Professor Judd's object in causing me to meet these three was to reassure me concerning the climate of India. They all looked fit enough, and Lydekker was florid and jovial.

Thomas Oldham It is pleasant to have met these men of the past who had worked under Thomas Oldham. Regrets are almost always useless; nevertheless, I do regret that I did not take advantage of these opportu nities to learn something of the general life and characteristics of Thomas Oldham, other than those that can be deduced from his deeds. Unfortunately, Oldham died before the Royal Society started publishing their fascinating volumes of 'Obituary Notices of Fellows of the Royal Society', and it is now difficult to obtain a picture of Thomas Oldham as a personality. We have already quoted *in extenso* the anonymous notice in Volume IX of the *Records* on his retirement, a note that summarises his activities in building up the Geological Survey of India and promoting the founding and building of the Indian Museum. His photograph shows him as bearded and of partriarchal aspect. It is evident from his

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[1] His last published paper involving chemical work is that on amblygonite in Kashmir *Rec. Geol. Surv. Ind.*, XXXII, p. 228 (1905).

achievements that he was held in great repsect by Government and by Society in Calcutta. He was, for several years, not only president of the Asiatic Society of Bengal, but he was also President of the Bengal Club.

SUMMARY OF PROGRESS : 1851 TO 1876

It will be appropriate to close this account of the growth and progress of the Geological Survey of India under the Superintendentship of Dr. Thomas Oldham during the 25 years, 1851 to 1876, by enumerating the principal achievements :

1. From a beginning of one Geological Surveyor to the East India Company (himself) and one Assistant (J. G. Medlicott) in 1851, the staff was rapidly built up, in spite of heavy casualities, and organised into a graded cadre of the following posts :-

One Superintendent (himself)
Three Deputy Superintendents
Thirteen Assistants, including
one Palaeontologist and
one Curator (and Chemist)

The type of officer appointed was of the highest quality and no less than five of them became ultimately Fellows of the Royal Society: W. T. Blanford (1874), H. B. Medlicott (1877), H. F. Blanford (1880), Valentine Ball (1882) and R. Lydekker (1894); Thomas Oldham was an F. R. S. (1848) before coming to India.

2. Oldham attempted to remedy the absence of provision for geological education in India by introducing a system of apprenticeship, in an attempt to recruit Indians to the Department. It was not until he had left that the first Indian trained in England (P. N. Bose) was recruited direct as an Assistant (in 1880).

3. With the aid of this staff a large proportion of India was surveyed geologically, often on maps of very inferior topography, during these 25 years, rendering possible the construction of the first authentic geological map of India (published in 1877). Geological maps were otherwise issued with the relevant reports (*Memoirs and Records*) except that Sheet 79 of the Indian Atlas (Trichonopolly, etc.) was published separately, in 1866-67, in four quarter sheets geologically coloured.

4. Oldham inaugurated three series of publications, all of which still persist. The first entitled the *Memoirs of the Geological Survey of India* began in 1859, and contains many classical descriptions of the geology of a large part of India. The second publication is another series of memoirs termed the *Palaeontologia Indica*, dating from 1861, and containing descrip-

tions of the fossil fauna and floras of India, written by specialists both in India and abroad, and profusely illustrated. This handsome series, in quarto size, is justly famous in the palaeontological world. The earlier numbers were grouped into separate series according to subject and region, and amount to some 89 memoirs and papers. These were followed in 1897 by a new series embracing all later memoirs and, now, amounting to 81, making a total of about 190 memoirs and papers to date. The third series of publication is the *Records of the Geological Survey of India*, dating from 1868 and now at volume 81. In addition, before he inaugurated the *Records*, Thomas Oldham published separate *Annual Reports of the Geological Survey of India*, and of the Geological Museum, Calcutta, starting with the official year 1858-59, and ending with that for the calendar year 1867, his annual reports after that year being included in the newly started *Records*.

5. In 1856, Oldham took charge of the Government Museum of Economic Geology, then housed by the Asiatic Society of Bengal at No. 1, Park Street, and expanded it to a Museum of Geology at No. 1, Hastings Street, Calcutta, where he had secured also in 1856, a headquarters home for what had hitherto been a peripatetic department. He obtained large collections of minerals, fossils and mateorites, by purchase, gift, and exchange with museums in Europe, and by collection by his staff in the field. The meteorite collection, he formed, has ever since been one of the world's principal collections of theses extra-terrestrial objects.

6. By gift from scientific societies and institutions by judicious purchase, and by exchanges arranged fort he departmental publications, Oldham laid the foundations of a very fine geological library: one which is certainly the finest such library in Asia, and is also because of its wide scope in including works and publications on mining and metallurgy and on many other branches of science, more comprehensive than any of the geological libraries in Britain.

7. Oldham was also the principal driving force and organised in the foundation of the Indian Museum in its present premises in Chowringhee Road, to which the Geological Museum and the offices of the Geological Survey of India were moved shortly before Oldham's retirement from India.

8. Oldham introduced the custom of sending officers of the department with trans-frontier and overseas expeditions e. g. W. T. Blanford in Abyssinia (1867-68) and Persia (1871-72), Stoliczka with the Yarkand Mission (1873-74) and himself with Phayer's mission to the court of Ava in 1855.

9. Oldham arranged for the despatch of collections illustrative of Indian Geology to the Vienna International Exhibition in 1873, this being a forerunner of other such contributions to International intercourse.

10. Oldham started the investigation of earthquakes in India as a duty of the Geological Survey and prepared the first catalogue of Indian earthquakes.

11. He prepared also the first list of thermal springs in India.

12. He advised both the central government and many provincial governments on a great variety of economic problems, especially those connected with the exploration and development of the coalfields, and with the possibility of iron smelting in India by European methods. Also, many of the Memoirs written by his officers contained descriptive accounts of the coalfields of India, thus fulfilling one of the principal objectives of the department in its early years.

13. He also published the first Indian mineral statistics.

14. During his period of control the foundations were laid of our nomenclature of the Indian geological formations, including the Champaners, Aravallis, Bijawars, Gwaliors, Cuddapahs and Kaladgis, Karnuls and Bhimas, Vindhyans, Gondwanas: the Jurassic of Cutch, the Tertiaries of Sind, the Punjab, the Sub-Himalayas, and lower Burma; the startigraphy of the Salt Range, and of the Higher Himalayas: with some attempt at the sub-division of the metamorphic or crystalline rocks series that form the foundations of the Peninsula of India.

15. In considering the nature of the work done on these Archaean crystalline or metamorphic rocks, we must remember that the Oldham era in India was the pre-microscope era of the Geological Survey of India, and that names were given to the old gneisses and schists with the aid only of a pocket lens and chemical tests and without the information provided by thin sections of rocks examined under the microscope[1].

It will be seen from the above that to his successor, as Superintendent of the Geological Survey, Thomas Oldham left a flourishing department, with a competent staff, permanent offices, a fine library, and a museum of ample collections. Their achievement was, of course, ren-

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1 The first paper in the publications of the *Geological Survey of India* in which the microscopic aspect of rocks is discussed or described is by a non-member of the department, Lieut. Colonel C. A. McMahon, later Lieut. Gen. C. A. McMahon, F.R.S., in a paper on the Simla Himalayas, *Rec. Geol. Surv. Ind.*, X, p. 222, 1877. The first paper illustrated with photographs of thin sections is another paper by the same author 'On the Traps of Darang and Mandi in the North-West Himalayas' *op. cit.*, XV, pp. 155-164 (1882).

In the Memoirs, the earliest paper with descriptions of the microscopic aspect of rocks is P.N. Bose's 'Geology of the Lower Narbada Valley' XXI, 1884, see pp. 51-54, and plate I. See also Fedden's 'Geology of the Kathiawar Peninsula', XXI, p. 94.

dered possible only by the generosity and far-sightedness of Government, evoked by the forceful personality of Thomas Oldham, and the fruitful results of the labours of his department. The full magnitude of Oldham's achievement can perhaps be best realised by comparing what he had to pass on to his successor with what he found on arrival in Calcutta in 1851, namely one peon, one writer, and a box of records in the Deputy Surveyor-General's Office[1].

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[1] See Sir Clement Markham's 'A Memoir of the Indian Surveys' (1871), p.154; but, see also chapter IV.

APPENDICES

Appendix I to Chapter III

[Copy of Despatch No. 8 of 1845 (Marine Dept.) dated 23rd December, 1845 from the Honourable Court of Directors of the East India Company.]

Our Governor General of India in Council,

With reference to your letter No.13 dated the 14th October, 1845, we have to inform you that we have engaged Mr. D. H. Williams to proceed to India for the purpose of making a Geological Survey of those districts in which Coal Fields are situated, with the view of obtaining accurate information respecting the resources possessed by that country for the production of Coal and determining in what manner they may be best turned to account.

2. Mr. William has been strongly recommended to us by Sir Henry De la Beche, Director General of the Geological Survey of the United Kingdon under whom Mr. Williams has been for several years employed. Sir Henry informs us that he has surveyed many of the Coalfields in Wales and in the West of England and has executed very valuable maps and sections relating to them. He also represents him as having been in early life engaged in working of Collieries and as being perfectly qualified to examine the Coal Districts of India, either geologically or practically as well as to superintend Coal works.

3. These high testimonials leave no doubt of the fitness of Mr. Williams for the important duty which it is proposed to confide to him, and we trust that his labours will have the effect of ensuring success to such mining operations as Government may think proper to undertake and of encouraging private speculators to embark in similar attempts.

4. Mr. Williams left England with the mail of the 20th of the present month (Decr.) and will proceed to Calcutta to place himself under the orders of your Govt. The period of his engagement is limited to five years. He is bound to serve in any part of the East India Company's territories to which you may direct him.

5. We have agreed to allow him a salary of £ 800 a year to commence from the date of his arrival in India exclusive of such travelling allowances as you may think reasonable; and we have also granted him £ 200 in aid for his outfit and passage to India, and we have guaranteed him the like sum for his return to this country on the expiration of his period of service. He has also been furnished with a set of Instruments such as he is likely to require in India, in order that he may not be prevented from immediately on his duties. These Instruments, a list of which is transmitted, are similar to those used in the Geological Survey of Great Britain, and have been selected by Sir Henry De La Beche.

6. One of the parts of the Deed of Covenant entered into by Mr. Williams is forwarded in the packet for your information and guidance.

Appendix II to ChapterIII

[Copy of a letter from Board's Collections, No. 121006, dated 23rd November, 1848 from Dr. J. McClelland to F. J. Halliday Esq., Secretary to Government Home Dept.]

Dear Sir,

I perceive the death of poor Mr. Williams announced in the news papers, and as his appointment by the Court of Directors originated in a recommendation of the late Coal Committee to which I was Secretary for eight years (from its origin to its close) and I may be supposed to know something of the grounds upon which the recommendation was made and the object required of such an appointment, I trust I may know without any impropreity be permitted to offer a few remarks on the subject in a private form.

The Late Coal Committee recommended the Government to move the Court of Directors to the appointment of an Eminent Geologist for a limited period of three years I think for the purpose of directing the public mind to a new field of enquiry in India, and the Committee particularly mention Mr., now Sir Charles Lyell, and Sir Roderick Murchison as eligible persons. The first had just returned from a tour in the United States, and the Second from a visit to Russia where he had been invited by the Emperor for the very purpose the Committee suggested his employment by the Court of Directors, and to guard against any misconception of this recommendation on the part of the Home Authorities the Committee ercommded that the Geological Socity of London should be consulted.

This was I believe done, and the Court opened a communication with Sir Charles Lyell on the subject of his employment which ended in some misunderstanding touching the expense. A reference was then made to Sir H. De La Beche employed in Superintending the Ordance Survey which led to Mr. Williams's appointment.

I have not the least doubt of Mr. Williams's merits. He had been employed under Sir Henry De la Beche in the Ordnance Survey of England but chiefly in the Bristol Coalfield. To this his experience and his mind I may say was confined, and when I heard of the appointment before I saw Mr. Williams I knew that the result would be disappointing because Sir H. De la Beche or any other man whose experience is confined to England, or any part of England can have no notion of the requisite qualification for Geological enquiries in such a field as India.

Before attempting the attainment of the exact number of inches in thickness of every seam of coal in any one locality, a general examination of the whole of the Coal districts of the Country is necessary in order to deter-

mine their bearings and relations with the great coal districts of other parts of the world. With this view in communication with Sir Charles Lyell I had from my own local knowledge of the position of every bed of Coal in the country laid down a plan of operations by which he or Sir R. Murchison would have been enabled in three Seasons to have completed all that was requisite in order to give both a practical and popular direction to such enquiries in India.

It is absurd to suppose that any one man could by his own personal labour a accomplish a work that can only progress with general improvement, and what we require on this subject is merely that public enquiry should be properly initiated.

My correspondence as Secretary of the late Coal Committee enabled me to know how much information might have been obtained from the Commissioners and other public functionaries scattered over the country had they passed any information or assistance in acquiring in formation regarding the Geological formation of their districts.

Perhaps under the present aspect of public affairs the subject may be allowed to drop, if not it will not I trust be considered presumptuous on my part of offer my services to the Government, for a period of three years, commenoing from November 1849 as I could not undertake at present any employment that would interrfere with the publication of the late Mr. Griffith's paper.

As my past life has been I may say a preparation for such duty, I would undertake the accomplishment of the object originally contemplated by the Coal Committee, (when Mr. Williams's appointment took place) in three years, and as I have suffered materially in not making previous stipulations for salary, the terms on which I would undertake the duty are 1,500 Rs. per mensum, staff exclusive of Military party and travelling allowance. I should therefore feel obliged by your submitting this proposition to His Honour The President in Council for such consideration as the subject may require.

Believe me, Dear Sir,

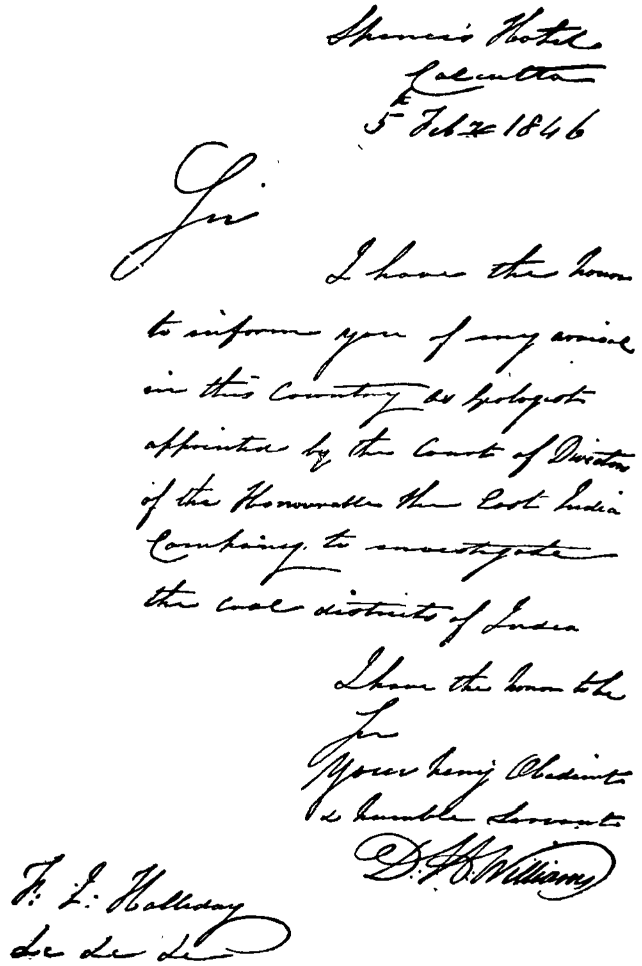
Yours Ever,
Sd/- McClelland.

Bhowaneepore,
23rd November, 1848.

P.S. This letter I suspect should have been addressed to the Secretary of the Government of Bengal, and His Honour the Deputy Governor, should have been adverted to in the concluding paragraph instead of the President in Council, but as it is only a private letter the informality perhaps will be excused.

Appendix III to Chapter III

Facsimile and Transcript of joining report by D. H. Williams



Spence's Hotel
Calcutta
5, Feby. 1846

Sir,

I have the honour to inform you of my arrival in this country as Geologist appointed by the Court of Directors of the Honourable the East India Company to investigate the coal districts of India,

I have the honour to be,
Sir,
Your being obedient & humble servant,
D. H. Williams

F. I. Halliday
&c. &c. &c.

Appendix I to Chapter IV

[Letter No. 189 dated Fort William, the 24th March 1851]

From:

The Secretary to the Government of Bengal

To

Professor T. Oldham.

Sir,

I am directed by the Deputy Governor of Bengal to transmit herewith, for your information, the accompanying copy of a letter from the Under-Secretary to the Government of India, in the Home Department, No. 291 dated the 21st instant, and to request you to proceed to the Sylhet Hills, with the view of prosecuting your researches there until the season will permit of your examining the Valley of the Damoodah. You will address your reports to this office.

2. At the time of the death of Mr. Williams the Establishment of your office was as following :-

Mr. Haddon	Rs.	350
Mr. Jones	Rs.	350
A sub. asst. surgeon	Rs.	100
A writer and interpreter	Rs.	50
	Rs.	850

3. Before Dr. McClelland made over charge of the office, the Establishment was as follows :-

Mr. Haddon	Rs.	350
Mr. Theobald	Rs.	100
Mr. Gomes	Rs.	100
	Rs.	550

The persons still borne upon your establishment are :-

Mr. Haddon	Rs.	350
Mr. Gomes	Rs.	100
	Rs.	450

4. Mr. Haddon and Mr. Gomes are at present on detailed duty at Purnea. But on your intimating to His Honor that their services will be required by you in your researches in the Sylhet Hills, they will be directed to join at Sylhet or Cherra forthwith.'

5. You are requested to report upon the establishment you may think it necessary to employ.

I have the honor etc.,

W. Grant
Secretary to the Govt. of Bengal

Appendix II to Chapter IV

[Extract from the Proceedings of the Government of Bengal in the Marine Department, under date the 25th Nov. 1852.]

No. 27 No. 130

From
The Superintendent of the Geological Survey

To
The Secretary to the Government of Bengal.

Dated September 2nd 1852

Sir,

I have the honour to forward herewith by desire of the Most Noble the Governor of Bengal, for submission to His Lordship, a **memorandum** on the system of work, to be adopted in the future progress of the Geological Survey.

And I shall feel obliged by its being laid before His Lordship for instructions thereon, as the arrangement necessary for field work during the coming season will mainly depend on the locality to be visited.

I have the honour to be etc.

(Sgd.) Thomas Oldham

Superintendent of the Geological Survey

Cherra Poonjee.
2nd Snetember 1852

Memorandum

1. The special object to Mr. Williams's appointment originally, would appear to have been a careful examination of the Several Coal fields of India, with a view of their being more extensively and effectively worked. But the subsequent despatches of the Hon'ble the Court of Directors, as well as the constant reference of questions for investigation relating to the mineral resources of the country generally, more especially since my own appointment, render it obvious, that our duty includes a general and systematic geological examination of the districts visited and a careful investigation of their mineral resources of every kind, whethere coal or otherwise, and of the possibility of their profitable application in developing the industry and so increasing the wealth of the country.

2. In this way, the important question of the Manufacture of Iron in this country was specially referred to me by the Honourable, Court of Directors, and certain localities were named which from previous information, appeared likely to prove favourable for such an understanding. On most of these localities I have already had the honour of submitting reports but there still remains one, namely, the neighbourhood of Siklee Gully near Rajmahal, which has not been visited and to the examination of which I would suggest that the attention of the survey should be directed as soon as the season of the year will admit of that place being visited.

3. For the proceedings of the survey subsequently, I would however solicity his Lordship's instructions. And by His Lordship's desire, I would submit my own views as to the system that might be advantageously adopted in the further prosecution of our work.

4. There appear to me *two* distinct plans which might be adopted. One in which the progress of the Geological Survey would successively and continuously embrace the whole of the country, so that after a time a general Geological map could be published. And *another*, on which detached districts should be examined, to which attention might be directed by any speical discoveries, or for any special object and thus a series of isolated maps, and reports on detached districts be prepared.

5. Undoubtedly, the former plan by which a steady continuous, and systematic examination of the whole country would be undertaken, is the one most likely to lead to sound practical results, (although in some cases not so immediately as the other system) and by which the most valuable additions to Geological science would be obtained. And unquestionably also, this is the plan which should be adopted in any country the topography of which was well known, and of which good maps existed. Unfortunately, however such maps exist only for a portion of this Country, and some important Geological districts have not yet been surveyed.

6. By the other system, more immediate information would be obtained regarding special objects, and peculiar localities, of which localities if needful maps could be prepared at the time, and by the staff of the Geological Survey. But the results thus obtained would necessarily be isolated, and deficient of any connecting link, and would therefore afford but little clue to a general knowledge of the mineral structures of the country country.

7. I am however disposed to think that the two systems might be usefully combined to a considerable extent.

8. In reporting (From Supt. of Geol. Survey To Secy. to Govt. Bl. No. 10 April 3rd 1851) at the request of His Honous the Deputy Governor of Bengal, on the establishment requisite for the survey, I had occasion to state that "for the efficient prosecution of Geological researches, it is essential" that "the Geologist should possess a topographical map of the district to be examined sufficiently detailed to enable him to record his observations and so to render them available to others". And I submitted an outline map, showing for what portions of Bengal, and the North Western Provinces such maps have been prepared, a copy of which I annex. From this, it will be seen that for a very large extent of Country including many districts in which rich metallic and other valuable deposits are stated to occur, excellent maps are ready for the Geoogist and of which I could venture to suggest that immediate use should be made, and that a continuous geological examination of the districts so surveyed, should be undertaken. With this object, I would propose that the Geological Survey, after the examination of the neighbourhood, of Siklee Gully, (as stated above) should proceed regularly to the West, including in their investigations all the country South of the Ganges, as far as the published maps extend. Thus the Geological information obtained could be at successive intervals transferred to the district maps published by the Revenue Survey and finally a general Map of Bengal prepared. Should such a system of operations be sanctioned, the work of each season could be so arranged, as that the examination would be resumed the following year without any delay whatever, and the time of the assistants not being occupied in the preparation of topographica Maps, the progress of the geological investingation would be so much the more expedited.

9. At the same time while the attention of the Assistants were directed to these districts the Superintendent could visit, and cursorily examine such orher localities as might appear likely to prove of practical value, or to which his attention should be called by any particular discoveries; such preliminary examination enabling him to decide as to whether it would be desirably to survey, or to go more carefully over the district again.

10. Should, however, the other system appears desirable, and the whole strength of the Survey be directed to any single locality, I would mention that from the papers already submitted to me there appear to be several districts of peculiar interest to the Geologist. The country of Assam, The Tenasserim Provinces and the districts adjoining the Nerbudda, are all stated to contain deposits of great value, and importance, and the examination of any of these would, doubtless, afford many valuable results.

11. By a reference to the records of the Geological Survey, I find, that subsequently to Mr. Williams's decease, his successor, Dr. McClelland was directed to carry out the plans previously marked out by that Gentleman, and to prosecute the search for *coal* in the neighbourhood of Hazareebaugh, and eventually proceed to the range of hill between the Nerbudda and the Taptee, and to the country near Codeypore and Koorba. These districts are at a considerable distance from the neighbourhood in which the survey has been recently engaged, and from the inaccessibility do not appear to me of such immediate interest as some of the others mentioned above.

12. I would, therefore, respectfully request instructions as to the mode in which His Lordship would desire me to proceed, and the districts to which I should direct my early attention.

13. In para. 13 of the letter above referred to, reporting on the establishment requisite for the Geological Survey, I stated that with reference to contingent charges, commissariat expenses etc. etc. I would prefer reporting again, after I had some experience in the field, and was capable of judging from personal observation. Since then the experience of last year's travelling has enabled me to form a definite opinion on the subject, and as this agrees perfectly with the results during former years under Mr. Williams I am tolerably satisfied of its correctness. I believe that the Arrangement, by which the Geological Survey is supplied with carraiage from the Commissariat and ordnance Departments is in many respects and objectionable one. However, excellent for military purposes, and in open countries, the heavy and valuable Commissariat Bullocks and the strong but very expensive ordnance carts are not well adopted for our purposes. They entail a very heavy responsibility one the person under whose commands they are placed, cause much trouble, and frequently delay in providing for them their established food, and give rise to much complication of accounts. The circumstances of our work also constantly changing, demand a frequent change in the arrangements for carriage etc.

14. Similarly, the number of persons employed as Chainmen; Measurers, for the purposes of a guard, messengers etc., is varied from day to day according to locality and season.

15. I would venture to submit that the whole system would be very greatly simplified if a stated monthly allowance were sanctioned to include all such charged allowing the Superintendent to vary the amount and kind of the carriage employed, the number of labourers of guard etc. according to the varying demands of his work.

16. Should such a plan meet with His Lordship's sanction, I am prepared to state, after a careful examination of the matter that for three hundred Rupees per month efficient carriage would be provided, and for an additional sum of one hundred and Fifty Rupees (Rs. 150) per month all charges for field guard, measurers, tent Khalassies, Chuprassies etc. should be defrayed. In the cold season when engaged in the field the cost would be considerable more than this per month, in the rainy season, considerably less, but such a continuous arrangment would enable suitable changes to be made from day to day adapting the establishment to the exigencies of the work.

17. I would state that the sum here mentioned, namely, Rs. 450 per month (to include all charges for commissariat and Ordnance supplied, for Khalassies, for chainmen, chuprassies, guard, etc., and for personal travelling expenses, house rent and office allowance) is about sixty rupees per month less than the actual cost of the same items as determined by the average of twenty four months experience under Mr. Williams's direction, and last year's experience under my own, independently altogether of the depreciation in value of the public stores, carts, bullocks, etc., which were valued at more than Rs. 2000 and which could not have been less than from Rs. 100 to 150 per month, or from Rs. 200 to 150 less than the previous cost per month.

With regard to tents for the survey, I beg to state that tents more suited to the purposes of our work than the regulation Military tents prepared for the Arsenal could be provided at a smaller cost. A sum of (Rs. 2000) two thousand rupees would sufficiently provide excellent tents such tents to be kept in repair at the cost of the officers of the Survey. I am led to believe that a somewhat similar plan is adopted with regard to the Officers of the Revenue Survey. But there is this essential difference that while the Officers of that survey seldom remain for a shorter period than some weeks in one place our work requires that we should be daily on the move. The wear and tear of tents is consequently much greater, and the amount of carriage required much larger.

19. The cost of carriage etc., estimated above is of course, independent of Elephants which cannot be procured excepting from the Public Department, but, which are perfectly essential for the progress of the survey.

20. I have above ventured to suggest a modification of existing arrangements which would materially simplify, and candense the account of the Survey, and enable much more satisfactory progress to be made. But I would at the same time, state, that should such a plan not appear desirable, the arrangements of last season were sufficiently effective for the purposes of the survey.

Signed. Thos. Oldham.
Supdt. of the Geological Survey

Appendix III to Chapter IV

[Letter No. 68 dated Calcutta, the 31st May 1856.]

From:
T. Oldham Esqr.,
Sudt. of the Geological Survey.

To:
Cecil Beadon Esqr.,
Secretary to Govt. of India.,
Home Department.

Dated May 1856

Sir,

Adverting to the 3rd paragraph of your letter No. 875 dated 23rd inst., I have the honour to submit herewith some considerations on "a general uniform plan on which I would propose that the operations of the Geological Survey should in future be carried out", with a few propositions for the improvement and extension of our establishment, and our labours.

I have the etc.
Sd/-

Calcutta
May 31, 1856.

[Propositions for the establishment of a General uniform plan on which the operations of the Geological Survey should in future be carried out ; submitted in accordance with ihe request of Government of India in the Home Department under daie of 23rd May, 1856.]

In submitting for the consideration of the Rt. Hon'ble The Governor General in Council my propositions for a General plan of operations for the Geological Survey, I would beg to refer to former communications of mine on the same subject on the 2nd Sept. 1852 (to Secretary to

Govt. of Bengal, No. 130, 2nd Sept. 1852). I had the honour to submit for the consideration of the Governor General in Council, a proposition of the same kind, and I swill taken the liberty of quoting from the letter on the present occasion, I there said, that there appeared to be two distinct plans which might be adopted, one in which the progress of the Geological Survey would successively and continually embrace the whole of the country, so that after a time a general Geological map could be published ; and another, on which detached districts should examined to which attention might be directed by any special discoveries or for any special objects and thus a series of isolated maps, and reports on these detached districts be prepared.

Undoubtedly, the former plan by which a steady, continuous, and systematic examination of the whole country would be undertaken is the one most likely to sound practical results (although in some cases not so immediately as the other system) and by which the most valuable additions to Geological Science would be obtained and unquestionably also, this is the plan which should be adopted in any country the topography of which was well known, and of which good maps existed. Unfortunately, however, such maps exist only for a portion of this country and some important geological districts, have not yet been surveyed.

By the other system, more immediate information would be obtained regarding special objects and peculiar localities, of which localities, if needful, maps could be prepared at the time, and by the staff of the geological survey, but the results thus obtained, would necessarily be isolated and deficient of any connecting links, and would therefore afford but little clue to a General knowledge of the mineral structure of the, country.

I proceeded to point out, "that for the efficient prosecution of Geological researches, it is essential that the Geologist should possess a topographical map of the country sufficiently detailed to enable him" to record thereon his observations and so "to render them available to other", and on this I based my recommendation that a regular and continuous extension of the Geological Survey should be carried on in all those districts for which maps existed, whether those prepared by the Revenue Suvey, or those of the atlas of India, with a view to the final publication of a general Geological map of the whole country. Under such a system I stated that the work of each season could be so arranged that the examination could be resumed the following year without any delay whatever and the time of the assistants not being occupied in the preparation of topographical maps the progress of the Geological investigation, would be so much the more expedited.

I have quoted the above statement partly to show how entirely the results which have actually taken place were anticipated at that time,

and partly because I do not see any reason to alter the plans then proposed in any essential particulars.'The direction in which the survey should proceed whether from east to west or the contrary will not in the least, affect the general system of operations. In 1852, I contemplated advancing steadily from the east to the west, because we were then engaged at the eastern extremely of the country on or near to the Ganges, since then we have been *interrupted in this regular progress and have during the last* season been engaged further to the west. I am, therefore, disposed to think that less lime would be lost by working from the districts now under examination than by returning to the part of the country we left in 1853.

I would, therefore, simply review my recommendation, that the, labours of the Geological Survey should be steadily and continuously, advanced over the country so as to embrace all those portions for which maps may be available, and that so far as such may be possible, no interruption to this systematic progress may be permitted each succeeding seasons' work joining on to, and forming a continuation of the past year's labours.

If a systematic extension of our operations of this kind be sanctioned it will be neither desirable nor necessary to fix with any great precision the exact locality or direction of our movements. These must to a certain extent depend on the geological structure of the districts examined which can not be known beforehand.

As seriously affecting these arrangements, the question of what maps should be used for geological purposes becomes important.

For a large portion of the country there are two distinct series, of maps now published. One series is published here in connection with the revenue survey. These are all lithographed, and of course, when the requisite number of copies has been struck off, the stone is destroyed. To prepare a copy of any of these with geological information added, would involve an expenditure equal to the original cost, and yet not give a permanent record.

The Hon'ble the Court of Directors have steadily carried out the publication of another continuous series of maps, on one uniform scale. forming what is known as the atlas of India. These maps are all engraved on copper, and the original sheets are carefully preserved. To these the addition of geological lines could at any time be readily made. In as much as these atlas maps must be considered as the permanent topographical maps of the country, it is I believe the desire of the Hon'ble Court, that the geological structure of the country should be shown upon them so that when completed, they should form a general geological as well as geographical map of the Indian Empire

This being the case, I presume that it would be advisable and that it whould be a primary object, wherever this did not interrupt the systematic progress of the survey to complete the geological examination of such portions of the empire, as have been mapped in this way, at an early date.

Another question arises from the fact that the maps of the two series referred to above are not on the same scale. The detailed maps of the Revenue Survey are all on the scale of one inch equal to one mile. The maps of the Indian atlas are all on the scale of one inch equal to four miles. It has hitherto been the custom to go over the country with a, detail and minuteness corresponding to the larger scale. This necessarily occupies much more time than if more cursorily gone over while this increased detail does not offer a fairly corresponding advantage since it cannot be permanently recorded.

I would, therefore, proposed that the larger scale should only be used in limited districts whose structure or importance may demand it and that the scale of the Indian atlas maps and those maps themselves whenever available should be adopted as the general basis of our geological examination.

I would also propose one uniform system for the publication of any geological reports and papers emanating from the survey. Hitherto my reports have been published some in the selections from the Bengal Government records, some in the selections for the Government of India records; some in the journal of the Asiatic Society and one in the cumbrous and costly form of a quarto volume. They thus form neither continuous nor a connected series, when printed among other papers, they become nearly inaccessible to Geologists, and are scarecely heard of beyond the local offices. I conceive that much advantage would result from their being printed spearately from other documents so as to form a series of geological papers. The size adopted for the Government selections, appears to me the most desirable, and if printed in this form, they would range not only with the Government selections, but with the valuable, memoirs of the Geological Survey of Great Britan or France etc.

I have frequently had occasion to represent the very serious difficulties under which our work in this country labours from the want of any fair literature of reference or any collections for comparison. These difficulties can scarcely be too strongly expressed. I may say that it is simply impossible to do justice either to ourselves on to the work entrusted to us without these aids. No report can be looked upon as even, approaching completeness which has to be drawn up without such help. From every district in which we have been engaged I have been obliged and at very considerable personal expense, to send to Europe specimens for comparison or analysis which there was no means of accomplishing

here. It is obvious how much delay and doubt must spriing from this. In every case months must elapse in many cases years, before a reply can can be had while in all the intermediate time a certain amount of doubt hangs over our labours nor is this merely a disadvantage for the moment it also prevents us from placing the results of our labours fairly before the public and prevents us from raising up in this country a desire for such pursuits and a willingness or ability to aid them.

In many other ways also the want of a Central and General department for Geological information is most seriously felt. In many detached districts throughout India valuable geological work has been done and from many of the servants of the Hon'ble E. I. Company most important contributions to our knowledge have been obtained. But these results are all scattered, are published in many different journals, British, Foreign and Indian, in travels, in reports and in many cases exist among the public records in Manuscrips, at present; the labour of months is often required to ascertain what has been already made known regarding any given locality and the time of observers proceeding into new districts is often wasted in re-examining and revisiting what has been for year before the public simply because they had no mean of easily obtaining this information.

The true and indeed the only remedy for these difficulties would be the establishment of some place in which everything bearing on the Geological structure or the mineral wealth of the country should be brought together and made easily accessible. Such a central office ought to be in connection with a museum of Geology both practical and theoretical, and I do not hesitate to express my deliberate conviction derived from several years experience of the working of similar institution in Great Birtain, that such an establishment is indespensable to the effective progress of the geological survey.

I believe also that it could not be satisfactorily conducted unless it be placed in connection with that survey. Not only will that survey be by far the most important, but almost the only source of its collections, and of its information but this information can only be fully available to the public when under the control of the same guiding head as the, field work.

I feel satisfied that a really useful establishment of this kind could be effectively carried out, at only a slightly increased cost, above the sum now paid by Government for a Museum of Economic Geology which is in almost every respect useless.

Another difficulty and cause of delay in our operations arises from the not unfrequent changes in the staff of the survey. During the five years I have had charge, I have lost four assistants one by death from the results of his exposure to this trying climate, the others from having ac-

cepted other and better appointments. I can state that none of those would have left the Geological Survey, if I could have held out to them better prospects than at present I can. Such changes unavoidably cause loss of time. Every new hand has to bee trained, and instructed in the pecularities of Indian Geology and in this way the loss is not only that of the assistants own work for the time, but also of the superintendents' while training the new-comer and I do not see how it is possible to avoid this, save by increasing the value of the appointments on the Geological Survey. The gentlemen engaged must all be men of extended education. Their acquirements are such that they could at any time command employment in this country on liberal pay, and with greatly less personal risk than they incur on the Geological Survey. Under these circumstances it cannot be expected, that they will look to their engagement in so dangerous and fatiguing a pursuit as a permanent one.

I would venture to suggest that this very undersirable feeling might be obviated by fixing a regularly graduated system of advance in pay to be given annually to each of the assistants whom the Superintendent, reported as having been attentive to his duties. I believe that if such a plan were sanctioned, no immediate increase to their present rate of pay would be required.

The plan I would suggest would be that when the establishment is completed each new assistant should join at the lowest rate of pay now sanctioned *viz.*, 300 Rs. per month, that after two years service (which will be sufficient to prove his aptitude for the work) an increase to his pay of 50 Rs. per month should be given each successive year on the certificate of the Superintendent of the Survey, that he had been zealous, and efficient in the discharge of his duties and that this increase should be given annually until the highest rate of 600 Rs. per month should be attained, but that nothing beyond that sum should be allowed excepting under very speical circumstances.

Under such a plan no future assistants should receive the highest rate of pay for eight years after joining, after which long training his services would undoubtedly be worth that amount or would not be worth retaining at all.

I feel convinced that such a system would both encourage the present assistants to greater exertion and would command a better class of man than the present pay can do.

I would add, that even if now sanctioned for the present establishment the full amount of the higher rates would not be payable until the year 1863.

Briefly to recapitulate, I would in compliance with the request conveyed to me strongly recommend :

That with a little deviation as possible the Geological Survey should be extended continuously and systematically to all those parts of the country for which maps exist of sufficient accuracy and detail to be used as Geological records.

That the maps of the atlas of India should be taken as the basis on which a general geological map of the country should be constructed, larger scale being only used for such limited districts as may demand greater detail and minuteness.

That an uniform publication of the report of the survey be adopted, separate from other documents not geological.

That a central office and museum may be established in connection with the Geological Survey where all specimens could be examined and arranged and where all geological information is easily accessible.

And that, the great delay and abstention of work now caused by the frequent changes in the staff of the survey arising from the very poor prospect of advancement held out to the assistants may be obviated by granting to them a prospective improvement in their pay conditional on their zealous discharge of their duties.

Although not immediatelly bearing on the arrangements for the existing staff of the survey, the present appears a favourable opportunity for setting before the Government the desirability of working out the plan of the survey on a wider basis.

If the view I have taken above be correct and that the maps of the atlas of India should be taken as the permanent records of the Geological work it would seem a necessary consequence that those maps should be made use of to as full an extent as possible and that the districts of the country for which they exist should be among the earliest visited. Now for the whole of the southern portion of the peninsula and for a considerable part of Bombay these maps have been published for many years. A continuous geological map of that area could, therefore, be prepared within a time limited only by the number of persons employed. The geology of that part of the country so far as anything is known of it, is inseparably connected with that of Bengal, the work formations of one pass into the other and to be properly understood must be examined in connection, one with the other. Geological Boundaries have in fact but little regard to political divisions and a large part of Madras must be examined before the full knowledge of the structure of Bengal can be obtained, while portions of Bombay must be visited if we would comprehend the relations of Madras Geology.

I would venture to suggest, therefore, that the survey should be extended into Madras, as soon as possible. This should be done by the

addition of three or four assistants who could be deputed there in charge of the General Superintendence of the head of the survey. An effective addition to the survey for such purpose, would not add to the cost, in as much as the general charges for Superintendence etc., would remain unchanged, more than Rs. 1600/- to Rs. 2000/- per month depending on the number of assistants employed.

With such a party rapid progress could be made if permitted to work steadily from point to point; and with the advantages of connection with Central Museum etc.

[**Abstract of salary and Establishment for Geological Survey for the month of May, 1856.**]

Honourable Company

Date	Name of officers	Amount	Total
June, 1	To Thomas Oldham Esq., Supdt. Survey for the month of May @ 1,100 Rs. per month, sanctioned by Hon'ble Court and Governor-General in Council 23 May, 1856	1,100-0-0	
	To arrears of advance of pay from Rs. 888-14-2 to 1100-00 per month from 5th day of March last being for March 26 days @ 211-1-10 or 234-10-10 and for April 177-1-0 211-1-10 sanctioned as above 388-2-10	388-2-10	1,488-2-10
	To House Allowance Ditto Ditto for the month of May 1856	60-0-0	
	To Travelling allowance for ditto.. ....ditto......	300-0-0	
	To Allowance for 4 elephants for ditto..........ditto....	120-0-0	
	To Allowance for field Establishment for ditto ditto sanctioned by Governor General in Council 5th April, 1856	225-0-0	
	To arrears for ditto ditto from 5th April to 30 April, being for 26 days 75 per month amount of increment sanctioned as above	65-0-0	770-0-0
	Calcutta, June, 1856	Total :	2,258-2-10

Appendix IV to Chapter IV

[Letter No. 69 dated Calcutta, the 31st May 1856.]

From :
Thomas Oldham Esqre.
Superintendent of Geological Survey.

To :
Cecil Beadon Esqre.,
Secretary to the Government of India,
Home Department.

Sir,

I have the honour to acknowledge the receipt of your letter No. 875 dated the 23rd instant giving cover to an extract from a despatch from the Hon'ble. Court of Directors No. 16 of 1856 and announcing to me the desire of Government to continue my services for an additional period of five years from the 5th March last at the advanced rate of pay of Eleven hundred rupees per month.

2nd. I accept the proposal, it being understood that all other terms of my covenants remain unchanged, I do so from the reasons I stated in June last namely, a strong desire to work out several questions of geological importance the full solution of which is only now opening up to me; I do so, abandoning Offices of higher remuneration, with duties of less danger, elsewhere.

3rd. In stating this I would beg to call to mind the facts that I solicited information as to whether the Government would desire a continuation of my services after the termination of my covenanted period, or after the 5th of March last, so long since as on the 6th June, 1853. I was early in September last, favoured with the decision fo the Govermot General in Council to recommend a renewal of my appointment for five years, at an increased rate of 1250/- Rupees per month. Acting on the persuasion that this recommendation coming from the Govt. whose full knowledge of my labours gave value to their opinion would have been sanctioned I have since then declined appointments both in this Country and in Europe. I am, therefore, compelled to express my regret that the period of my engagement should have been allowed to pass without the decision of the question, and my disappointment that the Hon'ble Court have not felt justified in confirming the more liberal recommendation of the Governor General in Council.

4th. I would state that I never have allowed any questions of pecuniary remuneration to interfere with my work and I would with confidence appeal to the authorities under whom I have been engaged in this country

to confirm this statement I have steadily and zealously devoted myself to duties, and have never scrupled to undertake any work or visit any district however malarious, where information was required. I trust I shall always be able to bring the same feeling to my duties. But I would also most respectfully but strongly express my belief that the excessive dangers to which the Officers of the Geological Survey are exposed the very great fatigues they undergo, the very unusual expenses to which they are subjected and the total absence of any prospect of advancement for them in this country have not been fully considered in fixing the emoluments attached to their appointments. The pay of the Superintendent is neither proportioned to the heavy risks and heavy responsibilities he incurs, nor is it commensurate with the emoluments attached to every similar Offiice in this country.

5th. I regret this result the more because the Hon'ble Court appear to have been influenced in their decision by an impression which I hope to show was perfectly erroneous. The Despatch says "We are apprehensive that the operations of the Department (The Geological Survey) may not have been carried out on a systematic and regular plan" and proceeds to urge the importance of giving such a character to the work of the Survey, a reference to the correspondence of this Office, shows, that so long since as September, 1852 at the earliest period when I felt that my local knowledge enabled me to form an opinion, I submitted a plan of operations which I was gratified to find met with the full approbation of the Governor General in Council. In accordance with that plan rapid progress was being made in examining and mapping Bengal and Behar when in 1853 by the express desire of the Hon'ble Court to obtain information regarding the Nerbudda valley as early as possible a deviation from this systematic plan was necessitated. I then drew attention to the fact, that such distraction of our force must "inevitably impede the general progress of our work". The Hon'ble Court cannot be more strongly impressed with the utter futility of any other than a systematic geological examination of the Country than I am. I have, never lost an opportunity of urging this, and I would eagerly join in the hope of the Hon'ble Court that such may be adhered to, that it should be so maintained with as little deviation as possible is precisely what every Geologist would pray for.

6th. The Hon'ble Court appear to be disappointed that a larger number of Maps and of Reports have not been submitted to them. I regret it exceedingly myself. But I think it will be sufficient to refer to the accompanying list of papers maps etc., prepared by me to show that much has been done. Distracted as our labours have been over Countries, ranging from 9° to 27° of N. Latitude and from 77° to 92° of E. Longitude it has been altogether impracticable to reduce these into any connected or continuous report. Again as regarding maps it must not be forgotten that we had much more to do than simply take existing

maps and use them as records for our geological work. In most of the districts to which our Survey has extended, no maps existed, and we have had to make a topographical as well as a geological survey. It is no exaggeration to say that one third of our time in the field was absorbed in this way. Thus all the Country of the Khasiah and Jynteah Hills, in the Nerbudda valley, in Pegu and Ava in Tenasserim etc., has been mapped solely from original surveys. In the greater number of the districts of Bengal, where we have been engaged, maps have existed, but they have been found so incorrect that nearly as much time has been necessary to improve them as would have sufficed to make an original survey.

On the whole, geological maps have been nearly completed for an area of more than 3000 square miles. Of these, about one half have been submitted to Govt. and part have been published. Some are in hand and will be ready this season, others have long been nearly finished, but not complete owing to the fact to which I have alluded above that we were stopped suddenly in our systematic examination of the Country. Some points were then unavoidably left unsettled, and these maps cannot be completed until these questions are decided, a few months steady work would enable me to complete maps of some thousands of square miles.

7th. I would also most strongly urge that we have been working in this Country under very great disadvantages in other ways. There is here no library for reference, no museum of specimens for comparison, no laboratory for analysis. Every geologist knows how perfectly essential such aids are, and how unsatisfactory all his work must be where they do not exist. At this moment there are in England specimens collected by me in 1852 which I have been obliged to send home for examination because there were no means of accomplishing it here, and still without such and examination our work can only be half completed. We are working under the same difficulty that would affect a tradesman without his tools or a physician without medicines and under these circumstances it is utterly impossible to attain the same progress which should be looked for in Europe.

8th. We cannot go on satisfactorily without such aids and the sooner they are organised the more satisfactory will be the results.

9th. Another great drawback to our steady progress here arises from difficulty of securing properly qualified assistants owing to the absence of any prospects of advancement for them. I have never had the full number of assistants sanctioned by Govt. at the same time. As one has been added, another has resigned or been carried off by illness. During the five years I have had charge of this Survey four assistants have been lost to it, one died from the effects of this climate; but of the other three I know that *not one* would have left the Survey had there been better prospects of promotion open to them in connection

with it. Every new hand has of course to be taught and trained, time is thus unavoidably lost and the result is I believe a greater cost to Govt. than a more liberal scale of remuneration would involve. No man would undergo the exposure and fatigue of the Geological Survey work unless from a real interest in his persuits. The services of a geological (surveyor) in India cannot be had for money alone for no mere pay would recompense for the daily risk of life and health, but if the full powers of the mind are to be given to the work there must be an absence of any feeling of difficulty or want of comfortables provision.

10th. In conclusion I would express a hope that a reconsideration of the matter will show to the Hon'ble Court that the defects of which they complain have not been the fault of the Geological Survey and also that the emoluments they have sanctioned are not commensurate with the heavy duties and great risks and responsibility imposed on the Geological Surveyor.

I have the honor to be etc.

(Sgd.) Thomas Oldham
Supdt. of Geological Survey of India

Calcutta
May, 31st, 1856.

Li sts of Reports Memoranda & c., furnished by Thomas Oldham Esqr. Superintendent of Geological Survey from 1851 to 1856

Date	Subject	To whom sent	Remarks
Arrived in India	March 5th, 1851		
1851 June 21st	On Coal and Iron Upper Assam.	Secy to Govt. of Bengal	
1851 June 21st	On Tin, Gold, Coal, Iron, etc. from Tenasserim Provinces.	-do-	Published in Selections from Records of Bengal Government No. VI, 33-34
1851 Oct. 24th	On Coal mines of Lakadon in Jynteah Hills with maps etc. etc.	-do-	Published in Selections from Bengal Govt. Records XIII, 45-57

Date	Subject	To whom sent	Remarks
1851 Dec. 2nd	On the Khasi Hills (Preliminary).	-do-	
1852 Jan. 28th	On grants of land for mining purposes in Tenasserim Provs.	-do-	
1852 May 22nd	On metereology, climate etc. of Cherra Poonjee.	-do-	Subsequently published with geological reports
1852 May 19th	On districts in Beerbhaom and in Damoodah Valley producing Iron-ore, with maps etc.	-do-	Published in Selections from Bengal Govt. Records. No. VIII, 1-34.
1852 Sept. 2nd	Memo: on general arrangements and plan of Survey.	-do-	Systematic plan of operations suggested.
1852 Dec. 10th	On limestone from Assam.	-do-	
1853 Feb. 3rd	Memo: on Survey of S. W. Frontier.	-do-	
1853 Feb. 3rd	On Copper and Lead Ores from Baragunda Mines.	-do-	
1853 May 4th	On Rajmahal District (Preliminary).	-do-	
1853 May 13th	On specimen of Copper, lead and antimony from Baragunda.	-do-	
1853 June 17th	On Iron and Iron-ores in Bombay Presidency with returns from 20 districts.	Secy to Govt. of Bengal	For communication to Bombay Government.

Date	Subject	To whom sent	Remarks
1853 June 27th	On Talchere coal, and its analyses.	Secy. to Govt. of Bengal	
1853 July 18th	On Geology of Mount Ophir and its gold bear ing rocks.	-do-	
1853 Aug. 1st.	Further considerations respecting Iron manufacture in Burdwan District.	-do-	Published in Journal of Asiatic Society, Bengal.
1853 Sept. 8th	On Iron-ores in Balgaum Lieutt Aytoun's researches.	-do-	For Commn. to Bombay Govt.
1853 Oct.	On gold and gold dust from Shwaygyeen, Pegu.	-do- -do-	Published in Selections from Records, Bengal Govt. XIII, 59-62
1853 Nov. 30th	On Geology of Khasi Hills with maps and ptates etc. etc.	-do-	Published in Quarto Volume
1853 Dec. 28th	On the coal etc. of the Teesta River, at foot of Darjeeling Hills.	-do-	Published in Journal of Asiatic Society of Bengal, XXIII, 201-203.
1854 Jan. 25th	On Geology of the Hill district of Rajmahal.	-do-	Published in Journal of Asiatic Society of Bengal XXIII, 263-283.
1854 Feb. 15th	Further reports on the coal etc. of the Damini Koh.	-do-	
1854 Feb. 16th	On analysis of Coal by Captn. H. C. James, with special view to gas yielding properties.	-do-	

Date	Subject	To whom sent	Remarks
1854 March 2nd	Memo: on the examination of The Nerbudda Valley.	-do-	Expresses the delay which would result from such diversion of labour without larger increase of establishment.
1854 May 27th	On road metal and stone for such purposes from Rajmahal Hills, Monghyr etc. etc.	To Chief Engr. of Lower Provs.	
1854 June 19th	On Mineral Springs in in the Kote Kangra district.	Secy. to Govt. of Bengal.	
1854 Aug. 7th	Memo: on lead metal and localities recommended.	Capt. Layard, Ex. Engineer Birhampore.	
1854 Aug. 10th	On Building stones, and their varieties in different districts in, Bengal.	Col. Goodwyn Chief. Engr. Lower Provs.	
1854 Aug. 16th	Reports on portions of Bhaugulpore, Beerbhoom and Moorshedabad with maps containing an area of more than 3000 sqr. miles.	To Secy. Govt. of Bengal	Being the Revenue Survey maps coloured-geologically.
1854 Aug. 30th	On minerals, ores, metals etc. from Martaban.	-do-	
1855 March 11th	On Gold Sands and other mineral products from Assam.	-do-	
1855 May 7th	On Iron from neighbourhood of Gyab.	Lt. W. Peile Ex. Officer.	

Date	Subject	To whom sent	Remarks
1855 July 19th	On Coal fields of the Valley of Nerbudda, preliminary report by Mr. Jas. G. Medlicott.	Secy. Govt. India Home Dept.	Published in selection from Records Govt. of India No. X, 12-29.
1855 Aug. 4th	On coal etc. from Thayet Myo on Irrawaddy.	Secy. Govt. of India Home	Published in Selection from Records Govt. of India. No. X. 99-107.
1855 Sept. 1st	On coal fields and tin ores of the Tenasserim Provinces.	Secy. Govt. of of India Foreign Dept.	Published in Selection from Records Govt. of, India. No. X, 31-67
1856 Apl. 14th	On the Iron ores etc. of Chandghur and Poonassa in Merbudda Valley.	Secy. Govt. of India Home Department.	
1856 May 7th	On lead from Amarapura with Analyses etc.	Secy. Govt. of India Foreign Department.	

In the above list nothing has been included which, however, short on brief the memorandum has not been the result of detailed examination and analyses these frequently occupying weeks while the results are expressed in a single word. There have also been constant references for opinions on specimens, or on collections, from public Officers, as well as private individuals, all involving considerable expenditure of time, and often requiring a careful examination, but which can scarcely come under the head of official reports or memoranda.

During these years, also, I have prepared for the press, and compiled maps, etc. for Mr. Williams's report on the Kymore Mountains and the Ramghur Coal Fields etc.

At the present moment, a long report on the Geological investigations made during the Mission trip to Ava, with maps, sketches, etc. is

in the hands, and is nearly ready, also reports on the districts in Cuttack, and in the Nerbudda Valley, which were visited during last Season.

In brief, since the summer of 1851, or in 5 working seasons, an area exceeding 9000 (nine thousand) square miles has been careully gone over, and mapped, a very large portion of this area has been surveyed topographically, as well as geologically and between 4,000 and 5,000 square miles in addition have been cursorily looked at.

Of this large area maps complete of more than 4,000 square miles have been submitted, and some published.

Of about 4,000 square miles, maps exist in this Office, very nearly complete, but which we have been prevented from finishing, by our attention having been diverted to other localities.

Of about 3,000 square miles, (nearly 4,000) of last season's work, maps are now in the draughtsmans' hands, and will be ready for submission during the present recess.

I believe I am prefectly justified in syaing that such a result is unprecedented and that, taking into consideration the peculiar climatical conditions, the constant changes in the staff of the survey, the untrained hands I had have to aid me, and the many great difficulties we have had to contend with in no country in the world has greater progress been ever made in a Geological survey.

But the districts examined being widely separated in position, and widely different in Geological age, no continuous or connected report on the whole was practicable.

Many of the notes given in the List above have been made available to the public through the colums of the newspapers, although not published in any more permanent form.

As to Geological results, it may suffice to say that in almost every case very great alterations have been made in existing ideas and the colouring of geological maps will in consequence of our investigations be totally changed. The Khasia hill coal, which had been described as carboniferous, is tertiary. The Tenasserim coal is also tertiary. The coal series of the Rajmahal hills, instead of resting upon trap. as described, is all covered up by it the whole of Central India and the Vindhyan Range belongs to a totally different epoch from that to which it has been assigned and other equally great changes have been described in the Geological relations of the Country examined. These are now detached results; a little further work will enable them to be united and reduced to system.